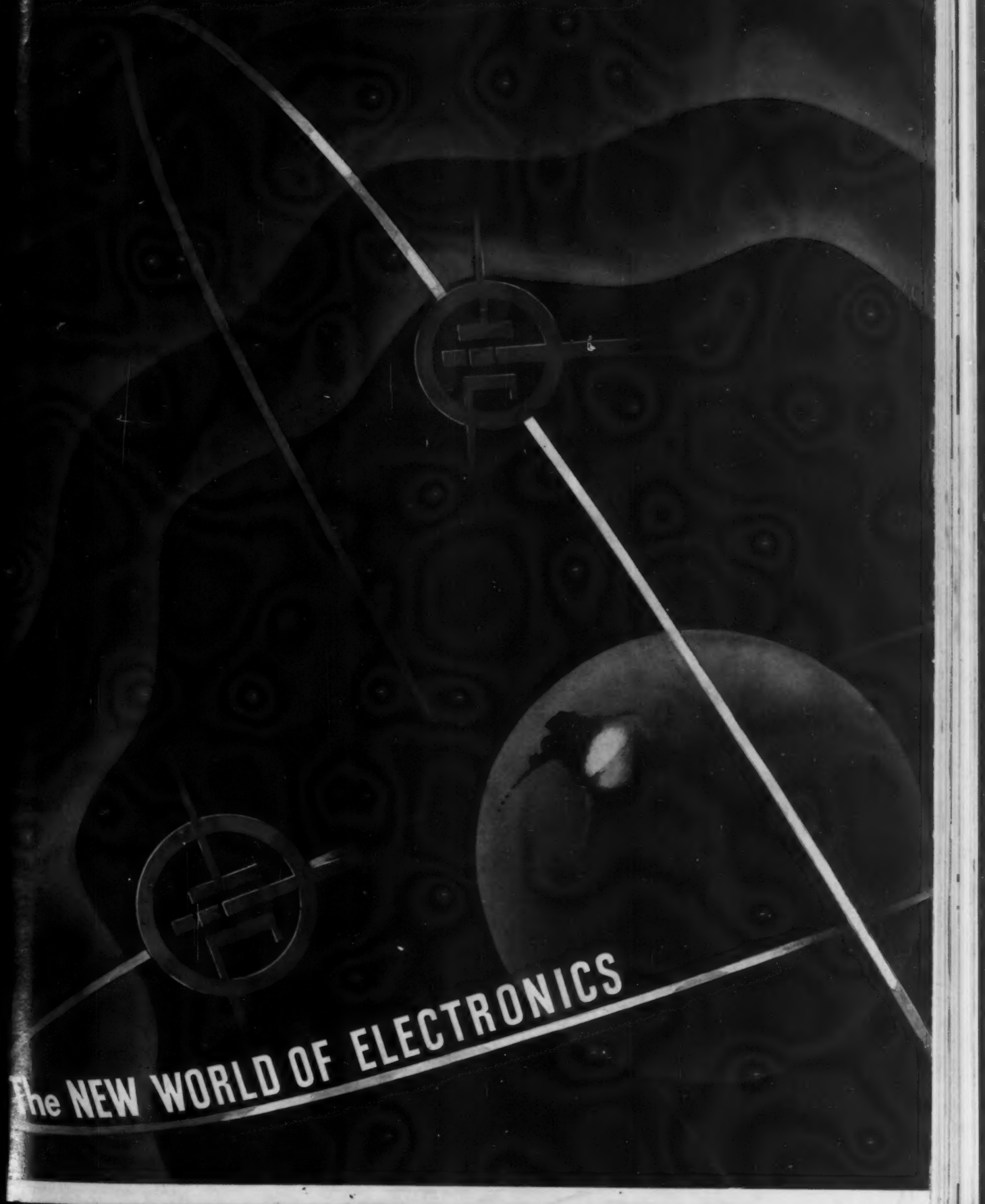
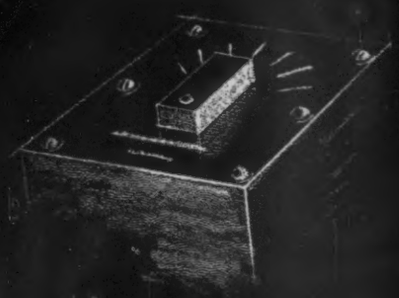
MARCH • 1945

electronics

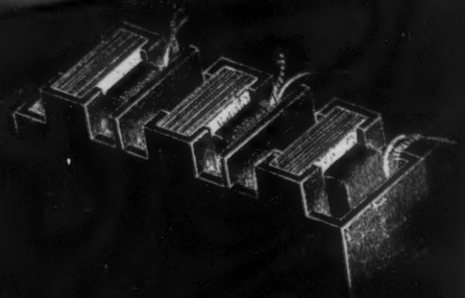


Combinations for Victory

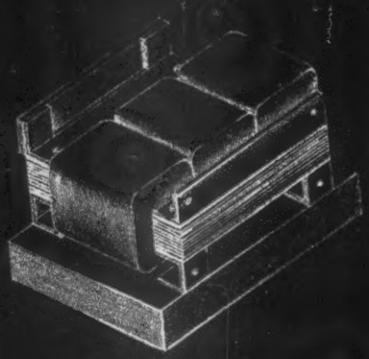
Savings in materials and machine time are vital to victory. Substantial savings can frequently be effected by combining elements. Typical UTC design refinements of this type are illustrated.



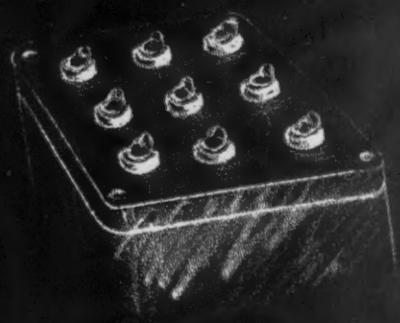
The design of this unit combines switch plate, name plate, and cover.



This unit employs a special die cast housing which combines the mounting of six units, eliminating twelve sets of brackets, twenty-four screws, and a special outer case.



UTC three phase to single phase transformers combine the mounting facilities of the transformer and condenser. This and electrical design reduced the volume and weight of the UTC design forty per cent compared to contemporary design.



Two reactors, four condensers, an two shielded transformers are com bined in this hermetically sealed co tainer. Separately cased, the volur and weight would be doubled.

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MARCH • 1943

FUNDAMENTAL BEHAVIOR OF WAVE GUIDES, by H. H. Skilling 76

Transmission of power at extremely high frequencies can be effected by single-conductor hollow tubes known as wave guides. Prof. Skilling provides a physical interpretation of the behavior of microwaves in such wave guides, and outlines the conditions for which such waves may be transmitted. The article is written for the intelligent non-specialist

WAR PRODUCTION THEME OF IRE-AIEE CONFERENCE 157

Engineers discuss war production, standardization, simplification, specifications and manpower problems in technical sessions. Getting the Most Out of Electron Tubes is topic of open discussion conference

NEW WORLD OF ELECTRONICS 81

The editors with the aid of numerous experts in the several fields using electron tubes, tell the non-technical reader what the electronics industry is by describing what electronics is doing in communication, in industry, and in research. A foretaste of what the future may bring will be found in this symposium

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WASHINGTON FEEDBACK

Radio has now really gone to war. The industry has emerged from the role of an important auxiliary to that of a vital and constantly expanding entity with a gigantic production program of its own. Expenditures for military radio alone are now running $200,000,000 per month, as compared with $15,000,000 monthly a year ago.

WPB—Manifestly, such an expansion has called for the setting up of an adequate radio organization in the WPB. While there has been no official announcement, broadly speaking the work of the division concerned and now in process of reorganization falls into six classifications. First, there is a program group whose function it is to keep informed of military electronic requirements; second, a distribution group seeing to it that critical materials are delivered to manufacturers at the proper time; third, a resources group making certain that the facilities of the industry are adequate to meet military demands; fourth, a field operations section which aims to solve problems for the manufacturer at his plant; fifth, an engineering advisory section which, among other things, keeps close watch on laboratory developments to avoid a time lag between the proven effectiveness of a device and actual placement in production; sixth, a foreign and domestic branch whose function it is to maintain broadcasting and home receiving sets on the present reduced scale through the provision of standardized parts.

It appears certain that Ray C. Ellis will continue to head the radio division. Gerald Miller will undoubtedly be in the program group; Sidney K. Wolfe is expected to head the resources group, aided by Captain W. A. Gray, Myron Whitney, Milton Lowenstein and Elmer Crane; W. H. Anderson and Frederick Boland are slated for important posts; Marvin Hobbs appears to be set for the engineering advisory section; Frank S. Horning is likely to handle field operations and Frank McIntosh is expected to continue as head of the home radio group.

FCC—In view of the existing stringent control of manufactured radio parts, there is much interest in the announcement by FCC that it has completed an 1100-page listing of surplus radio equipment in radio stations and available for rent or purchase. Chairman Fly describes it as "an informational set-up where everybody describes what he has and we give the information to everyone else."

Because of the size of the volume, it appeared impractical to distribute it to all licensees. So copies are to be sent to just a few selected stations and to inspectors in charge of the various radio districts.

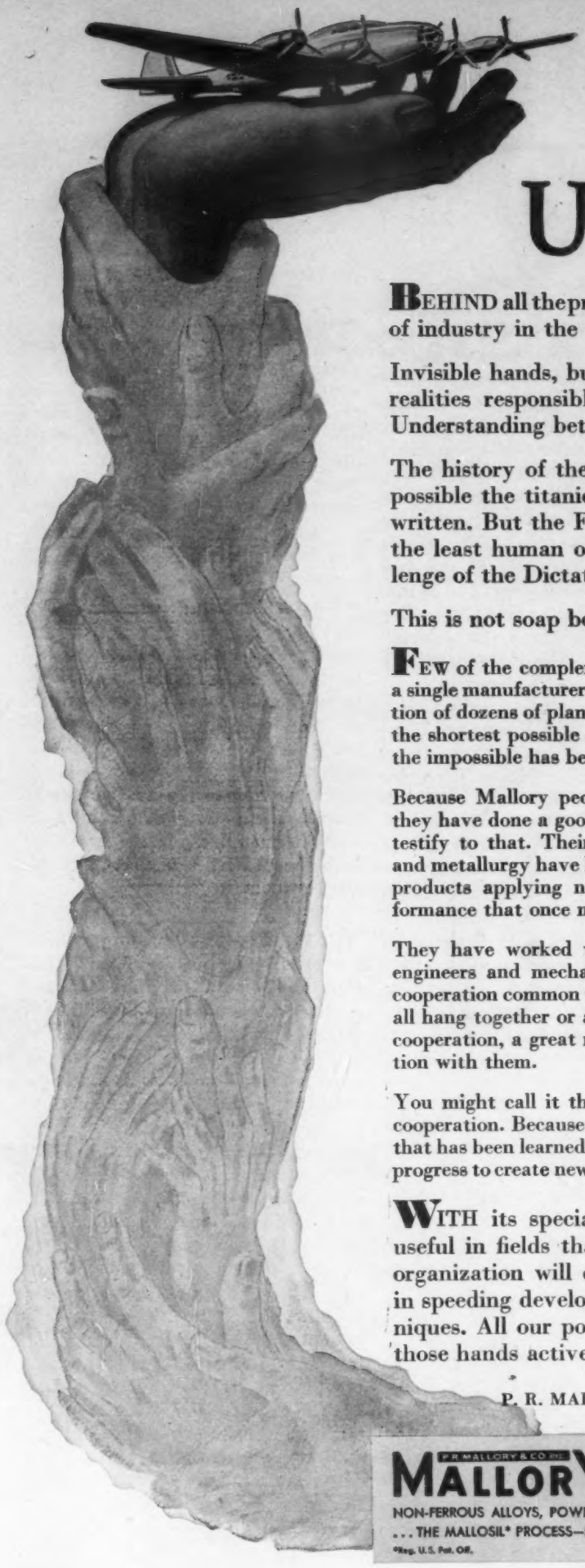
Draft—The War Manpower Commission has amended its occupational bulletin (No. 27) on essential communications services, issued to guide Selective Service local boards regarding occupational classifications of employees. The original bulletin, issued last October, listed as essential communication activities only telephone, telegraph, newspaper, radio broadcasting, newsreel and television services and the repair of such facilities. The amended bulletin includes 120 essential occupations in place of the original 92. It includes, among other services, protective signal systems which supplement fire and police protection to military, public and private industrial and commercial establishments.

Army—The Army reports that a Patent Board has been established in the Office of the Legal Director to review meritorious inventions by Signal Corps personnel. Regulations permit enlisted men to communicate directly with the Chief Signal Officer concerning unpatented inventions and frequently the Board recommends that a patent be obtained for the inventor at government expense. A number of suggestions for slight structural changes in Signal Corps apparatus have proved to be helpful during the redesign of equipment.

Amateurs—Radio amateurs have been requested to sell their shortwave communication equipment to a special purchasing mission of the Army Signal Corps, Service of Supply, for training purposes and operational use. Equipment needed consists of transmitters ranging in power from 25 watts and covering various bands in the shortwave range, as well as corresponding types of receivers and such radio components as capacitors, resistors and installation material. Especially desired are a-f and r-f signal generators, oscilloscopes, precision a-c and d-c voltmeters, ammeters and miliammeters.

Navy—Captain Carl F. Holden, Director of Naval Communications, has added an electronics branch to the Office of Naval Communications. Its purpose is to cooordinate the requirements of the Navy from the standpoint of precedence and allocation. It will work with the Radio Division of the Bureau of Ships. Lieutenant Commander F. R. Furth has been named Assistant Director of ONC in charge of the new branch.

CAP — WERS — Recent conferences between the Civil Air Patrol and the Office of Civilian Defense resulted in a plan to provide War Emergency Radio Service facilities to the CAP. With the concurrence of the Board of War Communications, the Federal Communications Commission has established a new class of stations designated as Civil Air Patrol Stations. In order to avoid serious interference both to CAP stations and civilian defense stations, a cooperative arrangement of sharing frequencies was worked out. Four channels, each 200 kc wide, at the upper end of the 112 to 116 Mc band, have been set aside for CAP stations. These channels are located at 115.3 Mc., 115.5 Mc., 115.7 Mc., and 115.9 Mc. If, in any particular locality, civilian defense stations find it necessary to use one of these channels, arrangements can be made with local representatives of the CAP to share the channel at 115.3 Mc.



Unseen Hands

BEHIND all the prodigious production and mighty accomplishments of industry in the war effort are the unseen hands of cooperation.

Invisible hands, but not ghostly. On the contrary, they are bright realities responsible for a gigantic step forward on the part of Understanding between men . . . and women in industry.

The history of the amazing industrial cooperation that has made possible the titanic achievements of War Production is still to be written. But the Future will record Voluntary Cooperation as not the least human of the answers made by free people to the challenge of the Dictator and his slave labor.

This is not soap box oratory. It is prosaic fact.

FEW of the complex mechanisms involved in war materiel are the output of a single manufacturer. Most of them represent the hitherto incredible cooperation of dozens of plants all working to the single goal of quality production in the shortest possible time. As folk have learned what cooperation can mean, the impossible has been accomplished with clockwork regularity.

Because Mallory people—from top to bottom—have learned to cooperate, they have done a good job in War Production. The Army-Navy "E" Awards testify to that. Their experience and knowledge in the fields of electronics and metallurgy have been put to vital use in innumerable war devices, mostly products applying new techniques and new materials . . . for critical performance that once might have been dubbed "black magic."

They have worked with military chiefs and governmental agencies, with engineers and mechanics, manufacturers and raw material suppliers—in a cooperation common to all, based on Poor Richard's realization that "we must all hang together or all hang separately." They have not been alone in their cooperation, a great many organizations have become Bachelors of Cooperation with them.

You might call it the "Higher Business Learning," this new philosophy of cooperation. Because—it will be important in post-war adjustments, when all that has been learned in war production will be turned loose on manufacturing progress to create new standards and satisfy the pent-up wants of war-sacrifice.

WITH its specialized knowledge of electronics and metallurgy useful in fields that apparently have no boundaries, the Mallory organization will offer "hands of cooperation" exceedingly useful in speeding developments for the betterment of products and techniques. All our post-war planning is based on the idea of keeping those hands active all the while.

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CROSS TALK

▶**NEW WORLD . . .** Last Fall returning from vacation, your editor found the office staff much upset. It seems that staff members were being harassed to death with visitors and phone calls asking what electronics was all about. Inquirers were advertising agency fellows, executives from big companies not then interested in electronics, people who had heard exciting broadcasts about the wonders of electronics, etc., etc. Right then came the idea that it was our job to satisfy this growing curiosity on the part of big business as to the significance of electronics. Active work on this March issue, "New World of Electronics" began.

To put all in one place an explanation of the science growing up around the electron tube was the first aim; then the purpose was to show the non-technical reader, in simple language, all the places where tubes aid communication, all the ways where tubes speed, simplify, and lower the cost of industrial processes. Writers of the individual sections and articles were chosen for their knowledge of certain vertical divisions of electronics; each was encouraged to let his imagination run a bit on the wild side when it came to summing up the future.

Obviously it is impossible to tell the whole story within the confines of one issue, and within present limitations on the use of paper; but it is hoped that the picture presented in the special section in this issue will give the non-technical reader a pretty broad idea of just what electronics is now and what it may be after the war.

The fact that an entire issue, except for our regular departments and the article on wave guides is made up of this non-technical story, need not worry our readers. Future issues will be just as technical as they have been since April 1930.

▶**PHYSICISTS . . .** Here is another, and we hope more correct, version of the reason why there are so many physicists rather than radio engineers in the several war-time laboratories concentrating on producing radio and radio-begot apparatus. (Version No. 1 was reported on this page in January.) It seems that men needed at first were those experimentally inclined fellows who can take on new ideas, work them out in breadboard style, making working models, however impractical these might be from the manufacturing standpoint. It developed, right off the bat, that many of our professional radio (receiver) engineers had lost this art. They had degenerated into men whose sole function was to take standardized circuits which everyone knew backward and forward, reduce them to manufacturing jobs—not to work on totally new ideas.

Best men for these jobs were the experimental physicists in college and industrial laboratories used to setting up their own apparatus; circuit model-makers, in fact. Radio engineers came much later, after the breadboard models were ready for reduction to practice.

▶**WAR . . .** Last month the page size of ELECTRONICS was reduced for the duration. The actual type page was not changed. A new type of binding permitted the book to lay open better than the old, and many readers may not even have noted the change. As the months go by, war will produce other evidences of itself.

There will be fewer bleed pages, both editorial and advertising. Once the correct number of impressions is off the press, the press will stop. There will be few overruns and few tearsheets. There will be no extra copies for those who lose or lend a copy now and then and don't get it back. A reader who lets his subscription lapse through failure to renew at the proper time will probably never get the issues which he missed when he finally does renew.

It is quite probable that circulation lists will be frozen; new subscribers then must wait to get on the circulation list until some other name is retired. A "waiting list" for ELECTRONICS is already at hand.

Physical Behavior of

Modern ultrahigh-frequency generators and transmission lines bear little resemblance to those at broadcast frequencies as this laboratory equipment at New York University illustrates

By HUGH SKILLING
Department of Electrical Engineering
Stanford University

WHEN a stone is dropped into a quiet pool, circular waves spread over the surface of the water. When there is an electric spark, or some other electrical disturbance, electromagnetic waves spread through space from the source. Radio waves travel out from a transmitting antenna in all directions, in three dimensions, and just as the water wave is circular, the spreading radio wave is spherical. If the radio wave strikes a plate of metal or the conducting surface of the earth, it is reflected. The wave pattern then becomes as complicated as when circling waves of water are reflected in complex patterns from the shore.

What is a Wave Guide?

A wave guide is a sort of speaking tube for radio waves; it is a means of guiding energy from one point to another without letting it spread out in all directions. There are hollow wave guides; there are concentric transmission lines; there are parallel-wire transmission lines: these are all wave guides in reality, although they are of different form. Before describing these it will be best to say a few words about waves in general.

Wave Facts

Radio waves (and other electromagnetic waves, including light) travel very satisfactorily through empty space. It is best not to inquire how they travel through empty space—how light, for instance, can come to the earth from the sun. Water waves are waves in water, but in what are electromagnetic waves? One may say "aether," but that is merely giving another name to empty space. We cannot do much better than to agree with Michael Faraday who said a century ago "Let us dismiss the aether, but keep the vibrations."

On the other hand, a great deal is known about these electromagnetic vibrations, whatever the medium in which they propagate. They comprise an electric and a magnetic field. A wave traveling freely in empty space consists of an electric field and a magnetic field at right angles to each other, both being at right angles to the direction of travel of the wave. For this reason the wave is called a transverse wave, analogous to a mechanical transverse

# of WAVE GUIDES

This paper is a non-mathematical explanation of how waves travel through hollow metal structures or solid dielectric rods known as wave guides. It also contains a discussion of the conditions under which a wave will or will not be propagated along a wave guide*

wave (as in a violin string), and contrasting with a longitudinal wave such as sound in a speaking-tube, in which the vibrating particles move back and forth along the direction of propagation of the wave.

It is quite impossible to have the electric part of the wave without the magnetic, or the magnetic field without the electric, for they produce each other: the electric field of the wave is produced by the changing magnetic field, and the magnetic field by the changing electric field, and they must necessarily go along together. They travel at a speed that is, of course, the speed of light; measured in English units it is about 186,000 miles per second, or in the metric system 300,000 kilometers (or 3×10^{10} centimeters) per second.

Characteristics of Plane Waves

The signal that reaches a radio receiving antenna is part of the spherical wave that spreads out in space about the transmitter. Assuming that the transmitted wave is allowed to spread freely through space, the receiving antenna receives only a small part of it. But a sufficiently small part of a large sphere appears plane, just as the surface of the ocean as far as one can see appears flat. From the point of view of the receiver, therefore, the arriving wave is practically a plane wave. This is fortunate, for a plane wave is the simplest of waves. Let us therefore discuss plane waves.

A diagram of a plane wave is shown in Fig. 1a. The electric field E is vertical, parallel to the Y axis; the magnetic field H is parallel to the Z axis; the wave is therefore traveling along the X axis. The cross-hatching of electric and magnetic fields indicates one plane of the wave, but it must be understood that the wave is not limited to this particular plane. If the wave is a sine wave, as it would be from any ordinary radio oscillator, it will have a distribution along the direction of travel (along the X axis) somewhat as shown in Fig. 1b.

To show the complete wave as it exists in three-dimensional space would require a combination of these diagrams, with the electric and magnetic fields shown in an unlimited number of parallel planes. This cannot well be drawn on a piece of paper, particularly since all the fields must extend to infinity, but it is not very hard to imagine. When a mental picture of this kind has been formed, it is a snapshot of a plane wave; to give it action it is only necessary to let the electric and magnetic fields pulsate so that waves of intensity travel through the field from left to right (parallel to the X axis).

The result is a plane wave. It is a specially simple kind of plane wave because it is plane-polarized, which means that the electric field at any point does not change direction as the wave passes. It changes magnitude, but is, in this illustration, always vertical. This wave is therefore said to be polarized with the electric vector vertical. Most radio waves are polarized in some such simple fashion, for the direction of the field is determined by the geometry of the transmitting antenna; but waves that have passed into the ionsphere and been reflected have acquired a more complicated form and are said to be elliptically polarized.

The electric field of the plane wave of Fig. 1a extends to infinity

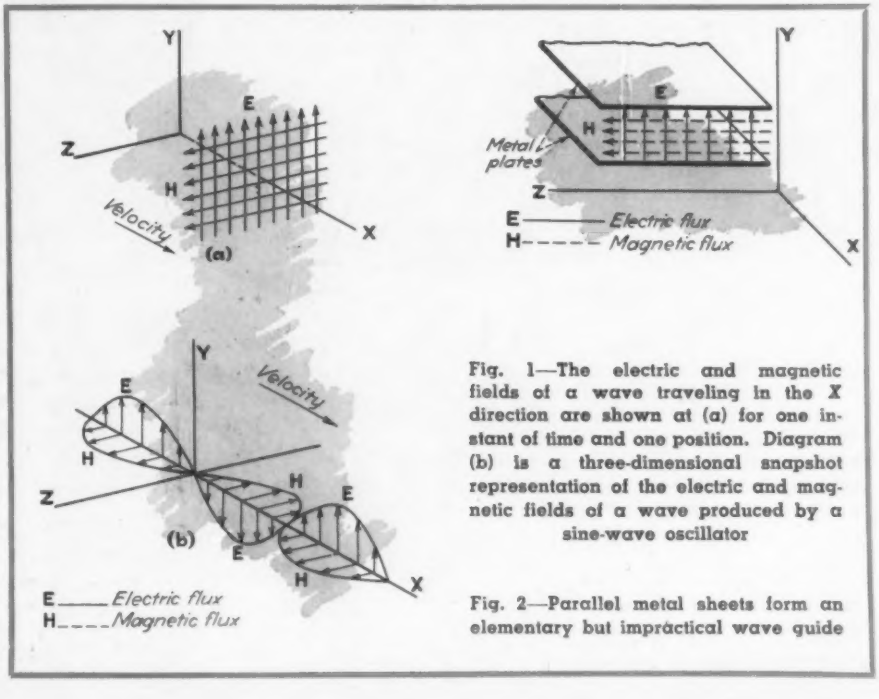


Fig. 1—The electric and magnetic fields of a wave traveling in the X direction are shown at (a) for one instant of time and one position. Diagram (b) is a three-dimensional snapshot representation of the electric and magnetic fields of a wave produced by a sine-wave oscillator

Fig. 2—Parallel metal sheets form an elementary but impractical wave guide

*This article has been prepared especially for ELECTRONICS at the request of its editors who found Prof. Skilling's recent book, "Fundamentals of Electric Waves" a stimulating treatment of modern u-h-f techniques

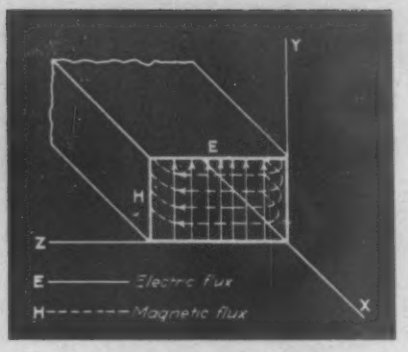


Fig. 3—Rectangular wave guide will transmit microwaves satisfactorily if the electric field is zero at the side walls and greatest at the center. This condition, illustrated in Figs. 4 and 5, can be achieved only if the wavelength is approximately equal to the width of the rectangular pipe

both upward and downward. This must be true of any such field in empty space, for an electric field cannot begin or end in empty space. The electric field begins where there is positive electric charge, and ends where there is negative charge.

One Metal Plate. If a horizontal sheet of metal is placed in the electric field, however, the field may terminate upon it. For this to be possible there must be a proper distribution of electric charge on the surface of the metal sheet on which the field is to terminate.

Two Metal Plates. By using two parallel metal sheets, the electric field can begin on one and end on the other, and an electric wave may thereby be propagated through the space between the metal sheets. Figure 1a becomes Fig. 2.

The metal plates of Fig. 2 form a kind of wave guide, for a wave that is started between them will continue to travel between them. But they do not constitute a practical guide, for they would need to be infinite in extent. It would be necessary for them to extend indefinitely to the left and right.

Four Metal Plates. One is inclined to say that if a pair of horizontal metal plates will form the top and bottom of a wave guide, cannot a pair of vertical plates be used as the sides? But this is not possible with a plane wave of the kind we have been discussing. Conducting plates can be placed perpendicular to the electric field, as in Fig. 2, and they will terminate the field without distorting it, but if they are placed in such a way that there is any component of electric field parallel to the conducting surface, if the metal plate is parallel to the electric field or at any angle except ninety degrees, the conductor will "short-circuit" part of the electric field and there will be distortion of the wave. Either a metal surface must be perpendicular to the electric field, or else the electric field at that surface must be zero.

Making a Wave Fit a Guide. Since it is impossible to take an ordinary plane wave and confine it within the four walls of a hollow rectangular wave guide, let us try the second of the above alternatives: let us reshape the wave so that the electric field is strongest in the center of a hollow guide, as in Fig. 3, and diminishes on either side so that at the left-hand and right-hand walls it is zero. If this is done, the necessary conditions are satisfied all around the guide, for the field is perpendicular to the top and bottom surfaces, and it is zero at both side walls. But can this peculiar kind of wave exist? We find that it can, and that it is merely the sum of two plane waves that travel along the wave guide at the same time.

Consider two sinusoidal waves. Each may be thought of as looking like the waves in a sheet of corrugated iron, or better, because it illustrates the motion, like waves in a rug when it is shaken. The two waves are illustrated by surfaces in Fig. 4, one lightly shaded or white and the other shaded red. The waves in the white surface are traveling almost directly away from the reader, while the shaded waves are traveling more toward the right. Two arrows in the figure indicate the directions of travel of the waves. The waves are cut off at the near edge by a vertical plane which contains the dotted line shown in the figure. They are cut off at the far edge by a parallel vertical plane.

How Two Waves Combine. Now for our purposes, each of these sinusoidal surfaces represents the electric field strength in a plane wave. The height of the surface above or below its neutral plane (the neutral plane is a horizontal plane through the dotted line of the figure) is a measure of the electric field strength. When the two waves are combined the total electric field is the sum of the two individual fields and is found at any point by adding together the field strengths of the component waves at that point. If the field of one wave is positive, and the field of the other is negative and of equal magnitude, at that point the total field strength is zero.

That condition, giving a total electric field strength of zero, is particularly interesting because it is found to exist all along the near edge of the waves of Fig. 4. Where the red shaded wave is positive (above neutral) the white wave is by an equal and opposite amount negative (below neutral). The same is true along the far edge of the waves shown, where they are cut off by another vertical plane. But in between, throughout all the middle part of the diagram, the waves add to something other than zero. At the points, for example where the crests of the waves coincide, the total is twice the crest of

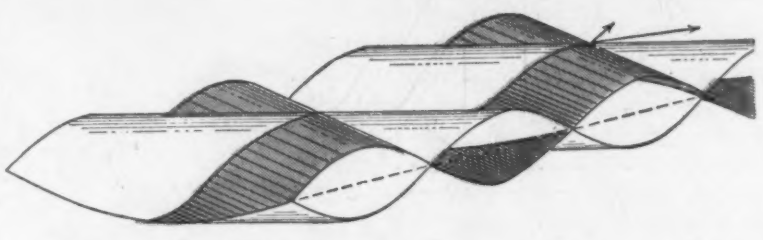


Fig. 4—Two sinusoidal waves traveling in the directions indicated by the arrows produce a resultant electric field meeting the requirements of a hollow wave guide. Note that the algebraic sum of the two individual waves is zero all along the near edges of the waves. The frequency and the wave-guide width determine the angle at which the waves cross

either alone. When the waves are added everywhere the total turns out to be a surface with hills and hollows as shown in Fig. 5.

Now this is exactly what is needed for a wave guide, for the electric field (represented by the surface of Fig. 5) is zero all along the side walls of the wave guide even though a large and useful wave may be going down the center of the guide. This exactly meets the requirements as indicated in Fig. 3. And it is, indeed, the type of wave that is commonly transmitted along a rectangular wave guide for practical use. Another and more complete way of picturing the wave is shown in Fig. 6.

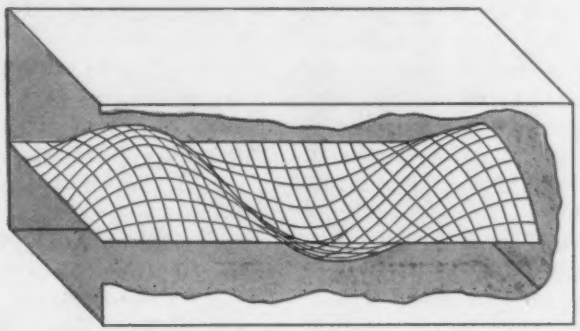


Fig. 5—Resultant surface of the electric field when the two waves of Fig. 4 are combined in a rectangular wave guide

Little has been said about the magnetic field of this guided wave, but the two component plane waves have magnetic fields and the magnetic field of the total wave is the sum of these components. As shown in Fig. 6 the magnetic field is made up of a series of sort of magnetic whirl-pools that travel along the guide. The lines of the magnetic field are all closed loops, as indeed magnetic lines must always be. The magnetic field is produced by the rate of change of the electric field, and the electric field in turn by the rate of change of the magnetic field, for this is how all electromagnetic waves travel.

Reflection of Waves in Guides. Now if this humped wave of Fig. 5, which is what one would see if the waves in a guide were visible, is considered to be the sum of two elementary plane waves, how do these elementary waves behave in the guide? First, as has been seen, they do not go straight along the guide, for they must cross each other. So each one goes at an angle, as in Fig. 7a, and each is reflected back and forth from one wall of the guide to the other, like light between two mirrors.

Angle of Reflection. The angle at which these elementary waves travel is determined by their frequency and wavelength. As may be seen in Fig. 4, the two waves are crossed at such an angle that they overlap one wavelength in the width of the guide. The crest of the red wave is directly above the trough of the white wave on the near side of the guide, while on the far side the same crest of the red wave is above the *next* trough of the white wave, one wavelength distant. So if the wavelength is short, corresponding to high frequency, the waves will not have to be overlapped very far and the angle α of Fig. 7a will be small. But if the wavelength is greater the amount of overlap in the width of the guide will be greater and the angle α will be larger as in Fig. 7b. In the latter case there will be many more reflections while the wave travels the length of the guide.

Group Velocity

One of the puzzling things about wave guides is that a signal travels along the guide more slowly than it would in open air, and this so-called *group velocity* is dependent upon the frequency and upon the width of the guide. But this ceases to be a mystery when the elementary waves are considered. In Fig. 7 it is apparent that an elementary wave following a zigzag path must go a greater distance in traveling from one end of the guide to the other than if it could go straight down the guide. It is therefore slower in reaching its destination. And since the number of zigzags is determined by both the wavelength of the signal and the width of the guide (for these two factors determine the angle at which the elementary waves must travel) these quantities affect the speed with which the signal is sent from one point to another.

Velocity Limits. It will be seen that the shorter the wavelength the more nearly the group velocity will be the same as the speed of an elementary wave, which is the speed of light This is the upper limit of speed. The lower limit is reached when the wavelength is twice the width of the wave guide, for if the wavelength is greater than that it will not be possible for the wave to travel in the guide at all. Let us examine the reasons why this condition must be so.

Cut-off Frequency. If the wavelength is greater than it is in Fig. 4 the elementary waves will have to overlap more than they do in that figure. The angle α will then be large, as in Fig. 7b, and the wave will not advance much between reflections from wall to wall. But as the length of half a wave (the distance from crest to trough) approaches the width of the guide, the angle α approaches 90 deg. At this frequency the wave merely goes back and forth across the guide, making no forward progress at all. The group velocity is then zero.

At still lower frequencies (greater wavelengths) there is no way to satisfy the condition that there must be no electric field at the walls of the guide, and consequently waves of lower frequency simply cannot be propagated along the guide. If such a wave were produced in the guide it would rapidly lose its energy and disappear. Hence the frequency at

which the wavelength of the elementary wave is twice the width of the guide is called the *cut-off frequency*.

Attenuation. Yet even above the cut-off frequency the waves do not travel along the guide without a certain amount of loss of energy. This is because there is electric current in the walls of the guide and consequently some resistance loss. There must be current in the top and bottom of the guide because the electric field of the guided wave terminates on charge, and as the wave travels the charge must flow from point to point; this constitutes current. Then too, each time the elementary wave is reflected from one of the side walls it loses a little energy. (This also is because reflection of the wave causes current to flow in the metal wall.) Since a wave near the cut-off frequency is reflected many more times in traveling through the guide than is a wave of higher frequency, it suffers more loss. It is for this reason that attenuation of a wave is very great if the frequency is near the cut-off frequency.

From this consideration it would seem that the attenuation of a guided wave would become less and less as the frequency is increased. And this is true to a certain extent, but at a very high frequency the rate of attenuation begins to increase again because of what may be called the skin effect at the higher frequencies.

For any particular wave guide there is an optimum frequency of least attenuation. This optimum frequency is something like two or three times the cut-off frequency. In practice, the frequencies used are usually lower than the optimum frequency, or, to express the same idea differently, the wave guide for use at a given frequency is not made as large as its most efficient operating size. This is a matter of economy.

Phase Velocity

If the waves in a rectangular guide were visible we would see a series of hills and valleys, as in Fig. 5, traveling rapidly along the guide. It is odd, in view of what has just been said about signals traveling at a group velocity less than the speed of light, that the humps in the wave would appear to be going faster than the speed of light. They would appear to advance at a speed known as *phase velocity*. Phase velocity is not a real speed of propagation—it is merely an illusion that appears because the elementary waves travel at an angle to the walls of the guide.

Ocean Wave Wall Analogy. Some years ago I stood by the sea near Gloucester, watching the Atlantic waves break against a concrete sea wall. The waves were not beating headlong upon the wall, but rolled in at an angle of perhaps thirty degrees. Each long wave dashed first against the wall at the south end, breaking at that point in a cloud of spray. As it rolled obliquely in, the wave continued to shatter itself upon the wall, progressively from south to north. It struck first at the south, but in a moment it was breaking at my feet, and then with a roar it was beyond me, rushing on until the last of the wave finally spent itself upon the north end of the wall.

To one who saw only the spray that flew above the sea wall it would have appeared that some violent action was progressing along the wall from south to north at an amazing rate of speed. From where I stood it was plain that nothing of the kind was happening, but that a relatively slow roller was crashing at an angle against the wall. The appearance of great speed resulted from the angle. The crest of the splash on the wall traveled along the wall much faster than the true wave velocity, and the apparent speed was equal to the true wave velocity divided by the cosine of the angle between the wall and the direction of travel of the wave. That apparent speed is phase velocity. On the wall of a wave guide, as on a sea wall, it is greater than the wave velocity if the wave approaches the wall at an angle.

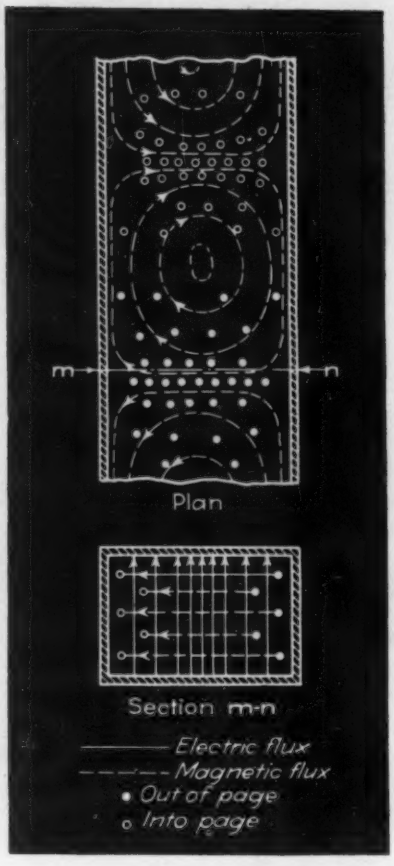


Fig. 6—Plan and cross-section views of a rectangular wave guide, showing both the electric and magnetic components of the resultant wave traveling through the guide

Code Signal Analogy. A signal, as a telegraphic dot or dash or a telephonic modulation, would not travel at phase velocity, but only at group velocity. If one could see a telegraphic dot traveling in a wave guide it would appear as a block of waves, with the block traveling at group velocity, while the waves within the block move forward with phase velocity, which is greater. New waves would be constantly coming into existence at the back of the block-shaped group, while the foremost of the apparent waves would, one after the other, reach the front of the group and simply vanish.

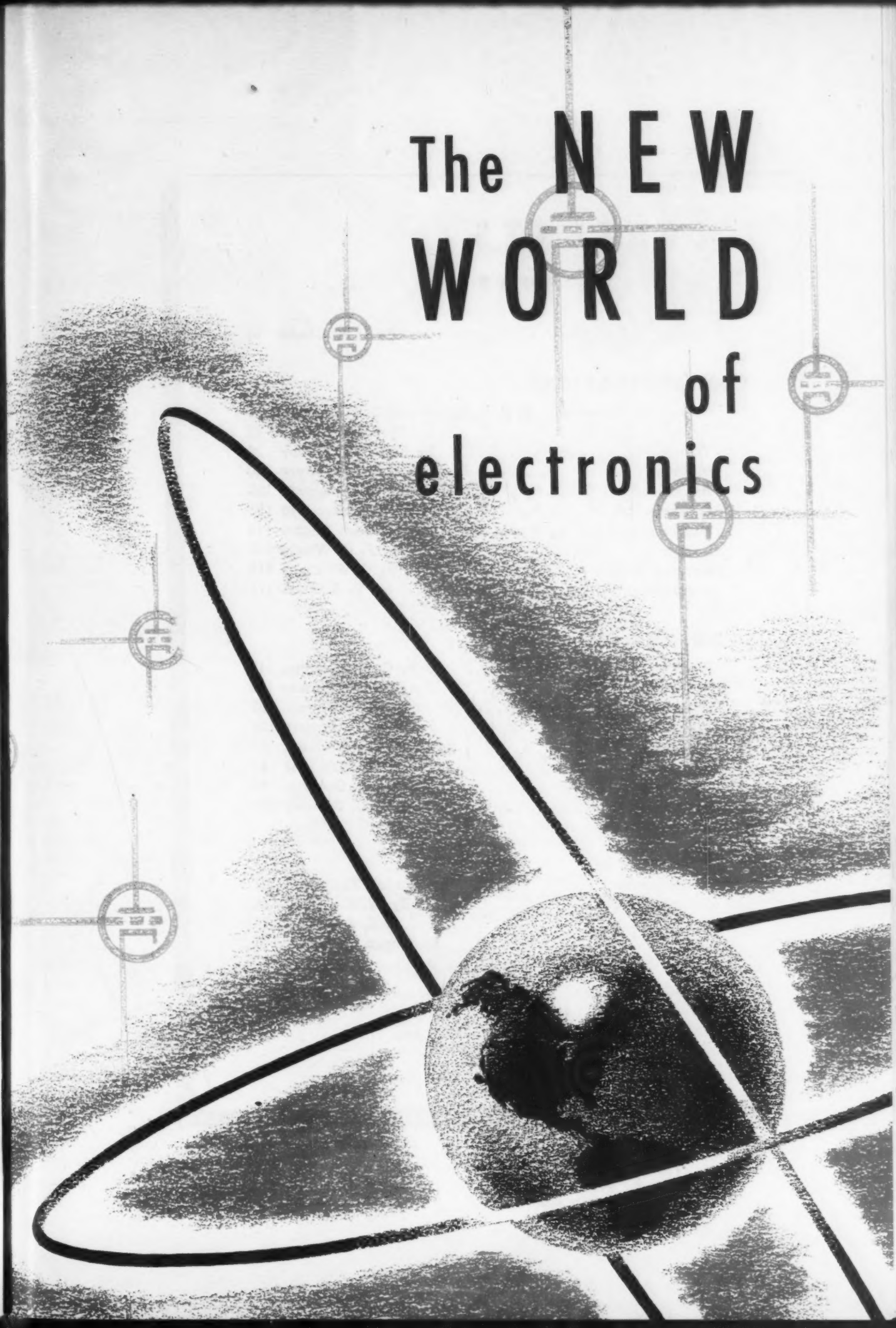
Caterpillar Analogy. I lecture to my class on this subject in the fall so that I can bring a caterpillar to class. When he can be coaxed to hurry across the lecture table, little waves ripple along his back from tail to head. The caterpillar moves at group velocity, while the little waves illustrate, after a fashion, phase velocity. In a guided wave, as in a caterpillar, the apparent waves go faster than that which they are carrying forward.

Circular Guides

In the previous paragraphs, guides of rectangular cross-section have been discussed. Wave guides may also be circular. Indeed they may be almost any shape, and one recent suggestion is to take a low, broad guide and wrap it up like a jelly roll

(*Continued on page* 260)

The NEW WORLD of electronics



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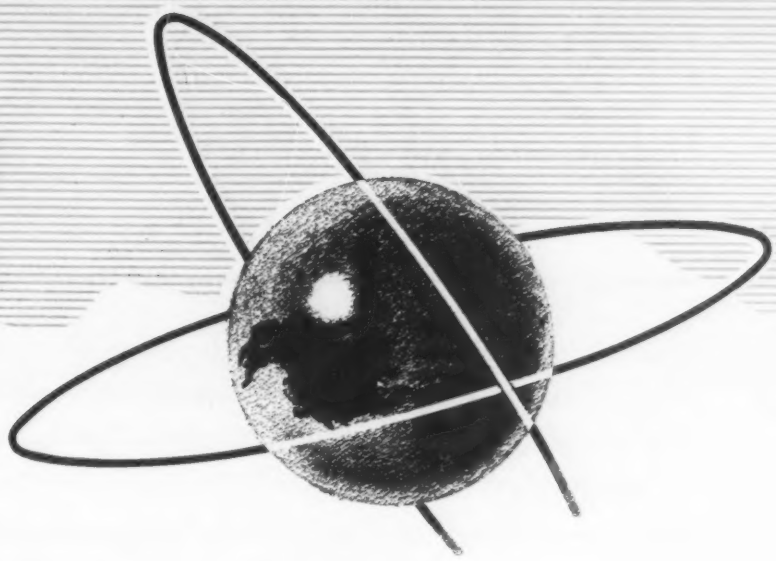


The NEW WORLD of Electronics

What is electronics? What can it do for me?

These questions are in the minds of manufacturers who are now vitally interested in every possible scientific advance for speeding up production, improving product quality, and for promoting safety. These questions are also being asked by manufacturers looking for post-war products to make and to sell, and who have heard, somewhere, that one of the new industries is going to be something called electronics.

What is the future of electronics?

This question naturally occurs to manufacturers who already have a stake in one or more branches of this industry but who, because of their preoccupation with problems directly related to the war, find it difficult to visualize the overall potentialities of this thing called electronics.

To answer these questions, the following pages have been prepared by the Editors with the aid of men with specialized knowledge in each branch of the field. These men have contributed liberally of their time and energy and have also allowed themselves to speculate somewhat upon the future.

The articles will tell the reader what electronics *is* by telling him what electronics *is doing* in the fields of communication, industry and in research. It is impossible to cover every phase of electronics here. There are few jobs at which electronic engineers have not tried their hands. Furthermore, there are many applications of electron tubes which, because of their current military significance, had to be omitted entirely. It is felt, however, that the many articles and illustrations (very largely added by the Editors) present a sufficiently broad picture of the field to enable readers with imagination to speculate intelligently concerning the future size, shape and complexion of electronics.

It should be evident that even without extension of many new developments, now secret because of the war, the field of electronics is certain to be among these contributing in a major way to an enhancement of the way of living enjoyed by Americans. There will be mass production items for general use; and there will be many applications to industrial processes.

Individual articles within this symposium, which have taken months to prepare, are neither highly popular nor highly technical. They steer a middle course which, it is hoped, will prove informative to industrial executives, merchandising personnel, production people and men at work on industry's machines. The very scope of the text, if not the detail, will serve to broaden the thinking of engineers who now have an intimate picture of one or more phases of electronics but who, because of their concentrated interest in these aspects, do not have opportunity to see the picture as a whole.

electronics

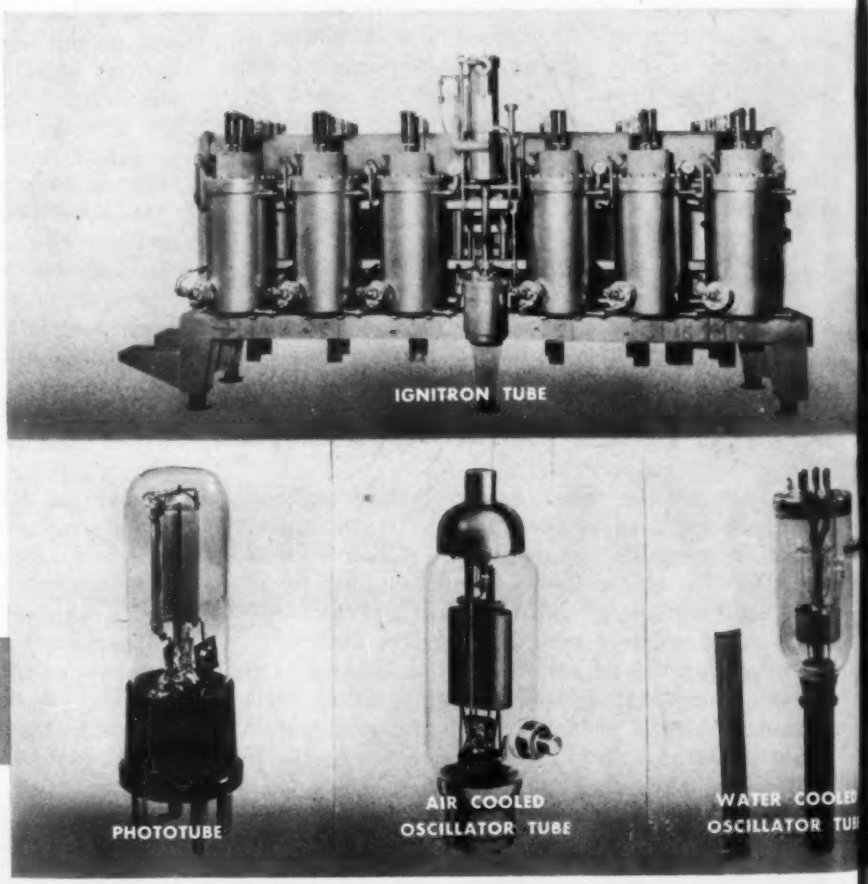
Today the electron, fundamental building block of the universe, is put to work by scientists and engineers to build a better world for the future. The great benefits already derived from wire and radio communication, x-rays, and navigation, television, and industrial electronics are but a prelude to developments making for a New World of Electronics

A SCIENTIFIC and fascinating drama of many acts has, in the last few decades, brought to us a new branch of electrical physics called "electronics". Because of its rapid growth and its frequent overlaps with other fields, this new science is difficult to define.

Whether "electronics" is a branch of electricity or includes electricity, depends greatly upon the scope of our definition. Most people, including some of scientific training, think of electronic as limited to the science of electronic and gaseous discharge phenomena in vacuum or low pressure tubes. We often hear people speak of electronic devices, meaning equipment containing vacuum tubes. Any such understanding of the scope of this science would place it as a branch of electricity. A broader definition would be: *electronics is the science relating to discharge phenomena of, and phenomena initiated by the action of, free electrons.* This more inclusive scope, generally acceptable to physicists and electrical engineers, will be assumed in what is to follow. It should be pointed out, however, that the knowledge of physical science, gained since the acceptance of the electron theory, seems to justify a realignment of the main branches of physics and putting electronics, which might be defined as the science relating to the action of electrons, in a most prominent place.

Why should we distinguish between electricity and electronics when the phenonmena of both result from electronic action? The distinction seems to be that electricity becomes electronics when the electron does its work in the open. This rather universal idea of limiting electronics to phenomena involving free electrons is hardly justifiable. To illustrate: In a phototube *free electrons* are produced by light impinging on the sensitive cathode. This is electronics. In a cathode-ray tube, *free electrons* produce light from the screen. This is the reverse action and classified as electronics. On the other hand, radiation produced by ultraviolet rays exciting fluorescent materials, as in a fluorescent lamp, is not considered an electronics phenomenon as no free electrons are involved. Both fluorescent phenomena, however, are the result of electron action in the atoms of the material.

We still hear people say, "We make and use electricity without knowing what it is." Current and well-founded theories have cleared most of the mysteries, and we can now say with considerable confidence that electricity already exists as corpuscular charges in matter. Electricity is not made, but is merely separated



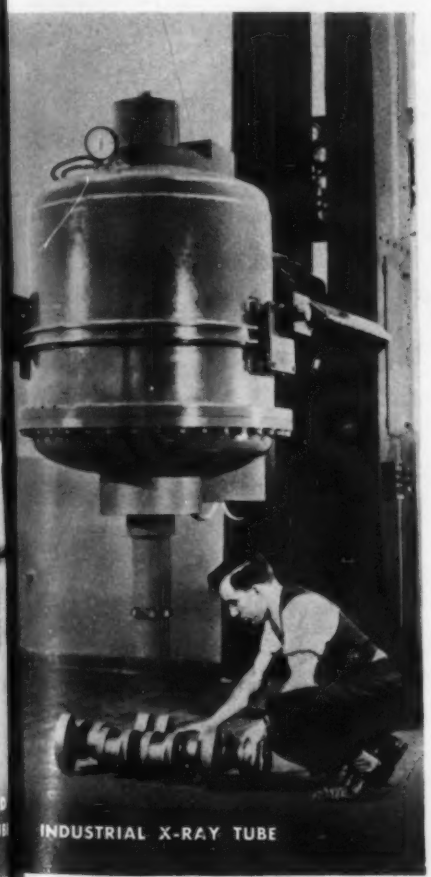
According to their function and power rating, electron tubes take various forms and sizes. The examples shown here are a few of the many electronic devices in daily use in communications, industry and research

—SCIENCE OF TODAY

By L. W. CHUBB

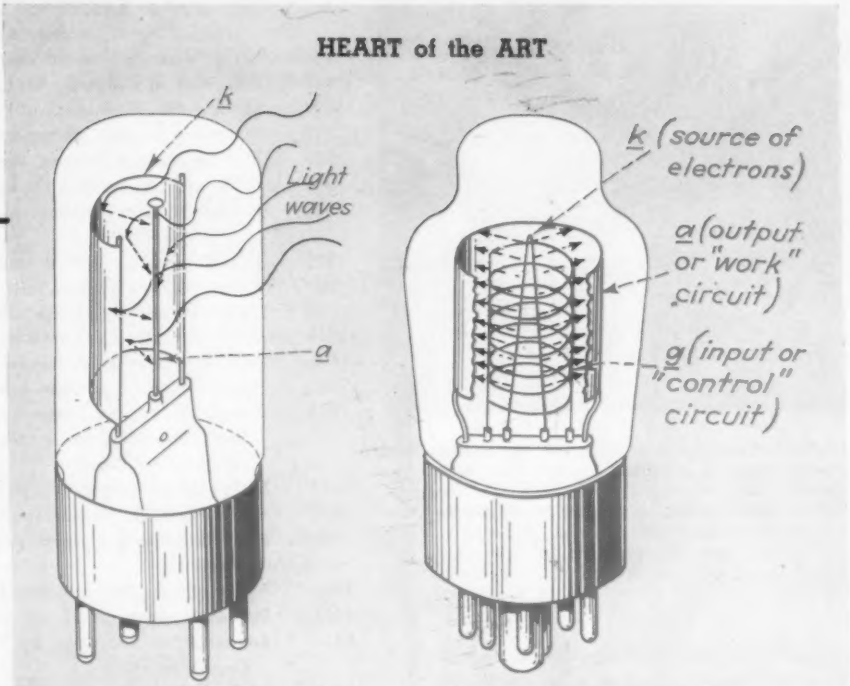
Director of Research
Westinghouse Electric and Manufacturing Co.

into its positive and negative components, making its presence apparent in some way. Electric current in conductors is the simple passage of electrons through the conductor. A charged body is merely one in which there is an excess or deficiency of electrons. Magnetic fields, light, x-rays, in fact all radiations, with the exception of those from nuclear reactions in the sun and stars, are of electronic origin. Substances absorb radiant energy because of the presence of electrons in their structure. Chemical reactions proceed because of the arrangement and number of electrons in the outer orbits of the atoms. The ferromagnetic atom of iron obtains its polar properties because of certain uncompensated electron rotations.



INDUSTRIAL X-RAY TUBE

HEART of the ART



PHOTOTUBE . . . Here, a light-sensitive surface serves as the cathode. Light impulses in the input circuit appear as electrical impulses in the output circuit

ELEMENTAL TRIODE . . . The broad usefulness of the tube stems from the fact that inertia-less electrons emitted by cathode *k* may be caused to flow to anode *a* with almost no time loss. Uni-directional flow phenomena permit functions such as "rectification" and "detection." Equally important, an additional structural element such as grid *g*, interposed between cathode and anode, may be used to increase or decrease the electron flow. a *small* amount of power applied at this point controlling a *large* amount of power in the anode or "work" circuit. This phenomena facilitates "amplification." Amplification may be changed to "oscillation", turning the tube into a generator of electricity

Since electronic action is the almost universal source of manifestations of energy, why shouldn't electronics be very broadly defined as *that branch of physical science relating to phenomena resulting from the action of electrons.* We would then include in electronics the formerly mysterious electricity, magnetism, radiations, chemistry, etc.

It is realized that this suggestion of the reclassification of the natural philosopher's basic science will meet with many objections. However, such a rearrangement seems logical in view of the present knowledge. Heat, electricity, magnetism, light—now subdivisions of physics—could quite well be included as subtopics of electronics.

For an understanding of electronics, in all its ramifications, one should consider the composition of matter. Modern physics teaches us the electrical nature of matter. We may say, with some slight limitations, that all matter is constructed of three fundamental entities: electrons, protons, and neutrons. Two of these three basic particles—the electron and the

were considered indivisible elementary particles until nearly the end of the last century. All objects, all matter built of them, show no evidence of their electrical nature and the internal forces that hold them together (and apart), until the electrons, which are relatively loosely bound to the nucleus, are torn away revealing the electrical components and give electrons and ions which may be put to work in many ways by the electronics engineers.

Origin of Electronics

Electronics was born of research. However, many of the commoner known electronic phenomena were discovered before there was a definite knowledge of the mechanisms involved. X-rays, accidentally discovered at the end of the last century, were so named because Roentgen could not explain the action. Electron emissions were discovered accidentally and independently by Edison and others. Photoelectric effects were discovered in 1887 when Hertz showed that ultraviolet light would lower the breakdown voltage of a spark gap, and it wasn't until 1899 that J. J. Thomson identified photoelectric emissions as electrons. These isolated and somewhat chance discoveries stimulated important physical research. In the same year that J. J. Thomson showed that photoelectric emission consisted of electrons, he measured the ratio of the electron charge to its mass. In 1902 Richardson measured the current carried by electrons from different hot metals. He later gave us the laws of thermionic emission and the flow of electrons in vacuum.

It was Millikan's classical oil drop experiment that really started the flood of research in electronics that greatly increased scientific knowledge of energy and matter. Millikan was first to measure the charge of the electron. This also gave us the mass, for the earlier work had shown the ratio of the charge to the mass.

Fleming's valve, de Forest's grid, Armstrong's inventions, and other well-known milestones have brought forth many electronic devices, combined with special circuits, which enable the electronic engineer to perform almost any electrical function.

Applications of electronic research and development have, in the last two or three decades, advanced engineering, communications and industrial processes in a manner never before equaled in such a short period of time. Today there are available vacuum tubes, gaseous tube and circuits having the necessary characteristics to amplify, generate, control, transform or convert electrical energy in almost any manner desired. Electronic devices and knowledge of electronics provide the auxiliaries to do things in a better way or that cannot be done otherwise.

It should not be forgotten that arc and spark discharges and ionization phenomena at atmospheric and higher pressures must be included in the field of electronics. Extensive studies regarding lightning in the field of lightning protection, circuit interruption, electrical precipitation, arc welding, and in many other fields, have removed the limitations to growth of our power and industrial activities. These studies have enabled us to meet the ever increasing requirements in the normal growth of the electrical industry and have been especially valuable in the enormous expansions necessary under the present war emergncy.

Electronics in the War

At the present time when all effort is directed toward war, it is interesting to reflect upon the part played by electronics. Probably the most important and obvious application of electronics is in the field of communications. The world-wide long distance system of wire and radio communications, as well as the many types for inter-communication between planes, ships, troops and trench, are of vital military importance. They have all been made possible by the application of old and new principles of electronics.

In the power industry, the adoption of electronic devices has been greatly retarded because of a lack of confidence in the fragile tubes used in places where a failure may result in serious disturbance or damage. In spite of a seeming prejudice to the new devices, industry is generally adopting electronics in many ways. It has proven particularly useful for regulation and control, for safety devices, for power conversion, light, welding, induction heating, etc. For the most important examples having to do with the war effort and involving electronic applications in industry, we might mention the enormous use of ignitrons to convert power for the production of aluminum and magnesium, so vitally needed for airplane construction. Another good example is the extensive use of fluorescent lamps for the efficient and economical lighting of war plants.

It would take pages to list and describe the multitudinous applications of electronics in research, development, and quality control laboratories. In almost any laboratory project one finds electronic devices for instrumentation or for performing other functions which cannot be accomplished in any other way. Tubes and special circuits are the tools of the research scientist.

In times of war, research and development are tremendously accelerated to bring forth new instruments of defense and destruction. This is particularly true in the field of electronics at the present time. A careful analysis would probably show that there has been more expansion in personnel for the study, research, development and productions of electronic devices than in any other war development.

Radio and electronics science has entered a new era. Radically new methods and most miraculous devices have been brought forth and applied as the tools of war. When the stories of these new things and the performance of them can be told, there will be many thrilling talks.

Fortunately the new electronic techniques, so useful in war, will have great peacetime value. Already many applications can be visualized and many other unforseen uses and possibly new industries will appear when the peace is won.

From time to time it is desirable in any important field of endeavor to have a series of articles which will record the progress, the present status and the future possibilities. In this issue, authorities in the fields of communication, industry, science, and measurement have presented articles closely related to or made possible by electronics—the science of today and the science of the future.

Researches in the perfection of the incandescent lamp in 1883 led Thomas Edison to observe the rectifying properties of the simple two element tube. This year marks the fiftieth anniversary of the "Edison effect" which was followed by an extremely active program of electronics research

proton—contain strong electrical charges. Each element has its characteristic atom, consisting of a small dense positively charged nucleus or core, composed of protons and neutrons, around which the negatively charged electrons rotate in quite definite orbits, just as the planets rotate around the sun in our solar system. The elements differ greatly in mass and complexity. Hydrogen is the simplest with a nucleus of one positively charged proton which holds one electron in the surrounding orbit. Next comes helium with a core of two protons and two neutrons surrounded by two orbital electrons. So it goes, up to the ninety-second element, uranium, having a nucleus of ninety-two protons and one hundred and forty-six neutrons, around which is a swarm of ninety-two electrons.

In all cases the balanced atom has as many protons in the nucleus as there are electrons in the neighborhood of the nucleus. Equality of the total positive charge of the nucleus and the negative charge of all the electrons results in a system having no external field, obscuring the electrical nature of the material.

It is not surprising that atoms

HIGHLIGHT DEVELOPMENTS IN ELECTRONICS

1883 Unilateral conductivity discovered by Thomas A. Edison and called the "Edison effect".

1884 First quantitative measurements of Edison effect made by Preece.

1888 Discharge of electroscope when illuminated by ultraviolet light discovered by W. Hallwachs.

1891 Term "electron" coined and used by George Johnstone Stoney.

1895 Discovery of x-rays by W. C. Roentgen.

1897 Braun tube, forerunner of cathode-ray tube, designed by F. Braun.

1897 Discovery of, and measurement of mass of electron, by J. J. Thomson.

1900 J. J. Thomson advanced the electron theory.

1903 Diode used as rectifier for high frequency oscillations by J. A. Fleming.

1903 Investigation of emission of electrons from oxide coated filaments by by A. Wehnelt.

1905 Albert Einstein offered interpretation of photoelectric effect.

1907 Introduction of grid in tube by Lee deForest.

1910 Millikan determined the charge carried by an electron.

1911 Child developed 3/2 power law of current flow, for plane electrodes.

1911 Research in wireless telephone undertaken by many investigators.

1912 Development of vacuum tube repeaters by engineers of Bell System.

1913 Armstrong and de Forest in United States, Franklin and Rund in England, and Meissner in Germany credited with invention of use of tube as oscillator.

1913 Langmuir developed 3/2 power current law for cylindrical electrodes.

1913 Molecular high vacuum pump introduced by Gaede.

1914 New York-San Francisco telephone circuit opened, using vacuum tube repeaters.

1915 Study of electron emission from pure tungsten, by Irving Langmuir.

1915 Diffusion pump introduced by Gaede.

1915 Regeneration described by E. H. Armstrong before Institute of Radio Engineers.

1919 Superheterodyne receiver circuit described by E. H. Armstrong.

1919 Use of second grid in tube suggested by W. Schottky.

1919 Mass spectrograph devised by Aston.

1920 Van der Bijl's book on "Thermionic Vacuum Tube" appeared; first book entirely devoted to electron tubes.

1921 KDKA broadcasts inaugurated era of broadcasting.

1921 Magnetron devised by A. W. Hull as electronic switch.

1923 Glass to metal seal, by W. G. Houskeeper, made possible high-power tubes.

1926 Screen grid tube developed by A. W. Hull and N. H. Williams.

1927 Cold cathode rectifier (Raytheon, BH) developed by C. G. Smith and V. Bush.

1928 Magnetrons used as u-h-f oscillator by Okabe.

1930 Cathode-ray tube developed to commercial practicality.

1930 Tube for measuring minute currents developed by G. F. Metcalf and B. J. Thompson.

1931 Electron microscope devised by E. Ruska in Germany.

1931 Variable-mu tubes invented by S. Ballantine and C. Snow.

1933 Acorn tubes for u-h-f use developed by B. J. Thompson and G. M. Rose.

1934 Image dissector tube described by P. T. Farnsworth.

1935 Metal cased tubes made available commercially.

1936 Beam power tube developed by RCA engineers; critical distance tube developed by J. W. O. Harries in England.

1936 Secondary multipliers developed by Farnsworth, Bell System, and RCA.

1938 Image iconoscope described by Iams, Morton, and Zworykin.

1939 Velocity modulated tubes described by Varian brothers.

1939 Orthicon developed by Rose and Iams.

1941 Million volt industrial x-ray unit made commercially available.

1942 Trigger tube using secondary emission developed by A. M. Skellett.

1942 Study of mechanism of emission of Wehnelt cathode by H. C. Rentschler.

Cornerstone of COMMUNICATION

TELEPHONE and TELEGRAPH
vast users of electronics

By FRANK A. COWAN
Transmission Engineer
American Telephone and Telegraph Company

NO time in the history of electronics has been more appropriate than the present for a review of the developments and application of this science in the field of communication. Each year in the last quarter century has seen new and important inventions linking these fields together and increasing their effectiveness. Today so wide and varied are the applications of electronic devices in telephony that a detailed consideration of all of them is beyond the scope of this article but some idea can be gained by reviewing the major steps in the development of electronic communication devices and the more outstanding present applications.

Today the most important assignment for communications and electronics is the war. Communications for battle fronts, transportation, war production and essential civil activities are all part of this job. The services performed by the telephone system have become so much a part of modern business activity that they are accepted as commonplace.

The first application of electronics in telephony was in the telephone repeater and today the use of the vacuum tube as an amplifier is still perhaps its most important use since it is also the amplifier that makes possible the widely used multichannel carrier telephone and telegraph systems. The need for an amplifier to strengthen the voice currents was apparent almost from the start of telephony. The early telephone repeaters employed a mechanical type of amplifier. First tested with success in 1904, a total of 41 such repeaters had been installed for use in the Bell System by 1910. The early work had paralleled Richardson's now-classic work on the laws of thermionic emission. The possibility of securing improved operation by substituting electronic coupling and control for mechanical coupling led to the orderly and imaginative research by Dr. H. D. Arnold. Employing mercury arc devices by July 1912 he had produced an amplifying element of this type which was used commercially to a limited extent. His attention had also been called to the audion of Dr. Lee deForest. Although it was a relatively crude instrument incapable of being used as a repeater, Dr. Arnold recognized its possibilities and undertook the development which resulted in the production in 1913 of the first prac-

AMERICAN TELEPHONE & TELEGRAPH COMPANY
RADIOTELEPHONE CIRCUITS
(January 1943)

To Europe
New York to London
" Berne
" Madrid
" Lisbon

To South America
New York to Buenos Aires
" Santiago
" Rio de Janeiro
" Lima
" Paramaribo
Miami to Colombia (Barranquilla, Cartagena, El Centro
" Venezuela (Caracas)

To Pacific
San Francisco to Hawaii
" Australia

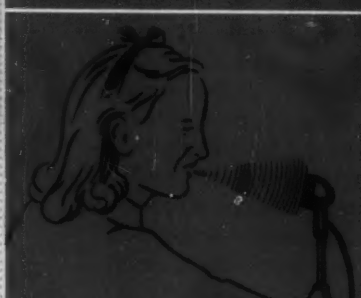
To West Indies
Miami to Bahamas (Nassau)
" Dominican Republic (Trujillo)
" Haiti (Port au Prince)
" Jamaica (Kingston)
" Puerto Rico (San Juan)

To Central America
New York to Panama (Panama City)
Miami to Costa Rica (San Jose)
" El Salvador (San Salvador)
" Guatemala (Guatemala City)
" Honduras (Tegucigalpa, La Lima)
" Nicaragua (Managua)
New York to Bermuda

TELEPHONE

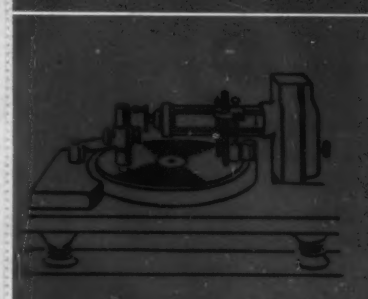
CARRIER-CURRENT

MOTION-PICTURES



SOUND

Wire and radio communication facilities serving the nation converge at the master control panel of the National Broadcasting Company

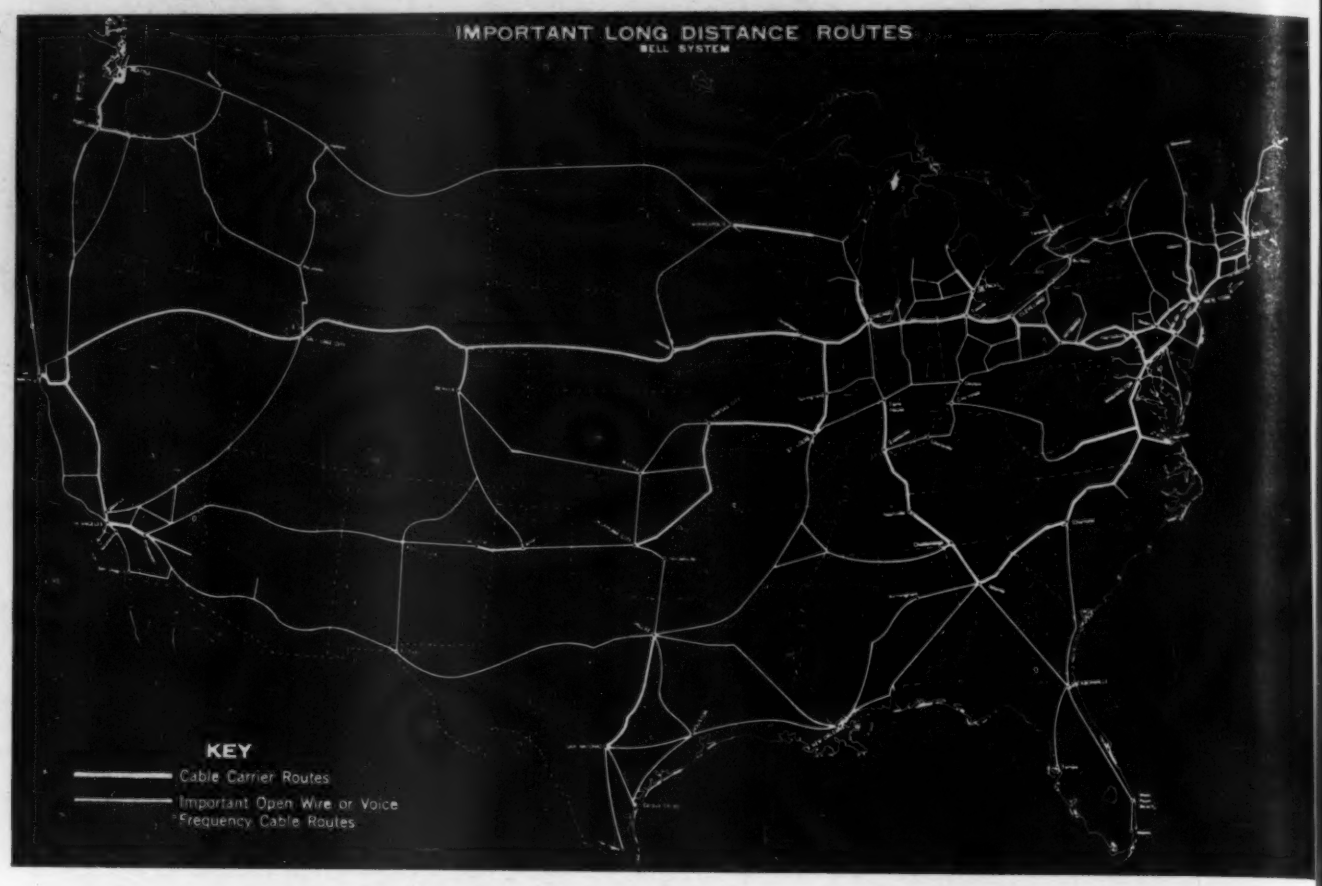


RECORDING

RADIO

TELEVISION

TELEGRAPH



Steadily, through the years, many miles of cable carrier telephone circuits have been added to the important open-wire or voice-frequency circuits. Some picture of the telephone's role in the production of ships, tanks and planes is carried in current telephone advertising which says, "It takes 10,000 telephone calls to build a plane"

tical termionic vacuum tube for use in a telephone repeater. This vacuum tube in 1915 was used in the opening of the first transcontinental telephone service, the first transmission of speech by radio across the Atlantic, and the first demonstration of a practical carrier telephone system.

These developments coming in the early part of the first world war were naturally turned into uses of war. Radiotelephone systems provided communication between airplanes and ground and telephone repeaters of the new type extended the utility of the wire communications systems at home and with the expeditionary forces.

Following the end of the war in 1918, attention was again turned to improving electronic instrumentalities and applying them to advantage in the expansion of the telephone and telegraph systems serving continental United States and in furnishing connections with other parts of the world. Advances in telephony and telegraphy were accompanied by the introduction and development of radio broadcasting, telephotography, facsimile and television. Important steps in this era were the demonstration of one-way radio telephone transmission from the United States to England in 1923 followed by the opening of commercial service in 1927, commercial telephotograph service in 1924, nationwide network broadcasting in 1925, the first intercity television in 1927 and two-way television between two stations in New York City in 1930. The two decades between the wars witnessed such extensive application of electronic systems to communications with accompanying advances in both fields that the contributions of electronics to this war dwarf the achievements in the earlier conflict.

Applications to Telephony

An amplifier can be made to serve two general purposes, (1) to increase the strength of signals above their initial level and (2) to compensate for losses encountered in the transmitting medium and to restore the strength of the signals to a usable intensity. The first application would, on the one hand, permit a 100-piece orchestra to be presented as though it were composed of a thousand pieces or, on the other make possible the detection or observation of minute sounds or currents which might otherwise pass unnoticed. Applications of the second class are of greatest importance where it is desired to overcome the inherent losses of the transmitting media and is the most important communications application. With improvement in amplifier design and adaptability, the two fields, separated initially only by the concept of relative levels, have tended to merge into one. The ready availability of amplification today has made it possible, in the negative feedback amplifier, to trade amplification for a stability and fidelity which would otherwise be difficult or impossible.

Various other and important applications of the vacuum tube in communications work are as variable impedance elements, relays or

switches, oscillators and modulators. Some of these uses are really the vacuum tube amplifier employed in a particular manner. This is illustrated by some of the present day oscillators which are multi-stage amplifiers arranged with external feedback or oscillation control paths and serve simultaneously as amplifiers and oscillators.

Probably the most unlikely place one would expect to find electronic devices in the telephone plant is in the familiar telephone instruments in his home. Yet hundreds of thousands of cold-cathode tubes are used in these instruments for the control of the selection and ringing on party lines.

Voice-Frequency Amplifiers

The voice-frequency amplifier has had a large effect upon the design of the telephone plant. First, it made it possible to establish a truly nation-wide telephone service which otherwise would have been impossible with the best types of line construction using the largest practical gauge of wire. Second, it made it practical to provide a large part of the long distance plant in cables employing small gauge conductors which possess virtues so obvious that it is always desired to employ them to the fullest extent. Thus circuuts in cable are inherently more stable than open-wire pairs because they are shielded from rain, sleet and snow and are less liable to physical interruption and to inductive disturbances from paralleling electrical structures. They are particularly desirable where the density of traffic becomes large enough to require many circuits over a route since a cable may carry many times the circuits possible with any reasonable open-wire construction. One disadvantage of cable as compared to open-wire construction, is a much higher attenuation loss resulting from the facts (1) that the wires of each being close together, the distributed electrostatic capacity is large and (2) that the resistance of the small gauge conductors is high. Consequently, until a satisfactory repeater was available, every reasonable effort was made to keep the amount of cable on a long distance circuit to a minimum. To avoid cable, the original transcontinental line was routed so as to avoid cities and the necessary intermediate test stations were located in the outskirts of larger cities.

In 1915 when the vacuum tube repeater was being introduced, the cables used for long distance service employed a relatively small number of heavy wires and their use was limited to short distances between the larger cities along the Atlantic Seaboard. With improvements in the design of the electronic telephone repeater, long distances and a larger number of finer gauge wires within a cable sheath were made possible and the field of use of cable was consequently greatly extended. After the close of the war in 1918 a program looking to the provision of long distance service over the heavier traffic routes in cables containing small gauge conductors was undertaken. In 1921 the cable network along the Atlantic Coast was extended to Pittsburgh, in 1925 to Chicago, in 1926 to St. Louis, in 1931 to Omaha, in 1932 to Dallas, in 1935 to Atlanta. This expansion of cables operating

(*Continued on page* 162)

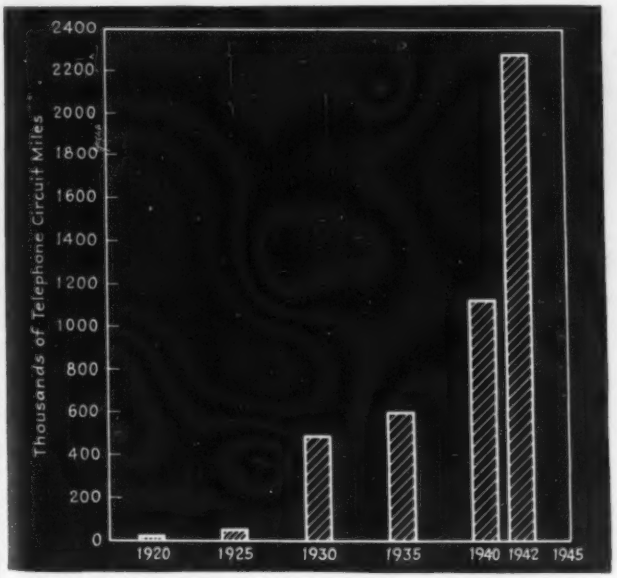
VOICE-FREQUENCY REPEATERS INSTALLED IN BELL SYSTEM

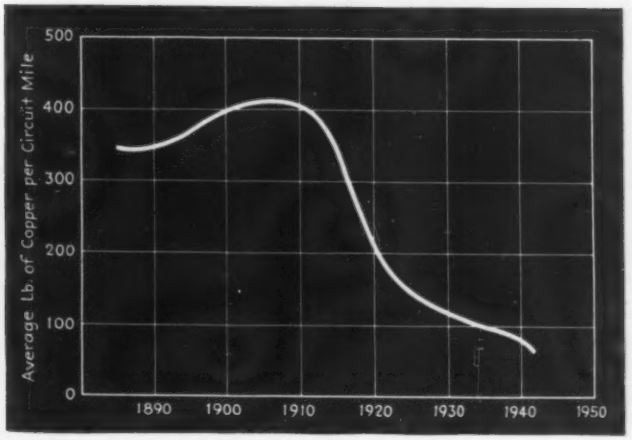
Year	*Total*
1908	16
1910	41
1915	136
1920	1,250
1925	7,500
1930	80,000
1935	102,000
1940	110,000
1942	123,000

Carrier Telephone Circuit Mileage

(Bell Telephone Systems)

Growth of circuit mileage using carrier telephone methods. Electronics provides the carrier frequencies, modulates them with voice frequency currents, removes the modulation at the receiver provides power for the tubes





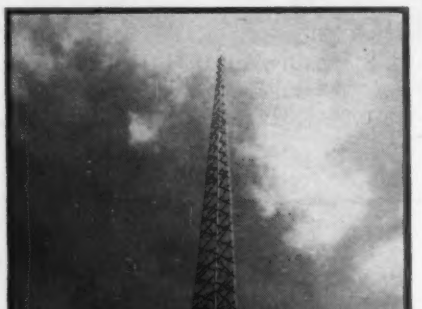
Copper in Long Distance Circuits

Electronics decreases the quantity of copper required for wire circuits. Had the 1915 rate of copper usage continued to the present and had the same growth continued, total copper used to the end of 1942 would have been 1,500 million pounds greater than actually used; equivalent to an entire year's output of United States copper mines in the 1930-40 decade

RADIO . . .

Out of the last war came practical wireless communication. The war in which we are now engaged is accelerating extension of service toward the higher frequencies. This will have profound influence upon many aspects of life in our time

By RALPH R. BEAL
Research Director
RCA Laboratories



OMEN—Radio antennas have always sought the sky. In these two photos are signs of the future. Present practice is to erect vast expensive antennas out in the country far from the center of population; the future trend will be to erect small, compact, inexpensive antennas on high buildings in the center of the area

THE foundations of radio's expansion in this war were laid during World War I. Then, radio was known only as a new and relatively undeveloped means of communication, employing the simple dots and dashes of code. Only one section of the radio wave spectrum, long waves, was available. The spark method of transmission, requiring vast amounts of electrical power, was inefficient and wasteful, according to modern standards.

But men of science, working under the pressure of war just as they are today, labored over development of the vacuum tube and of new electrical circuits. They studied radio wave propagation, so that new sections of the spectrum could be opened for use. In 1919, radio was ready for its first great expansion.

What was accomplished with radio in the two decades of peace that followed World War I is shown by what radio had to offer at the outbreak of World War II.

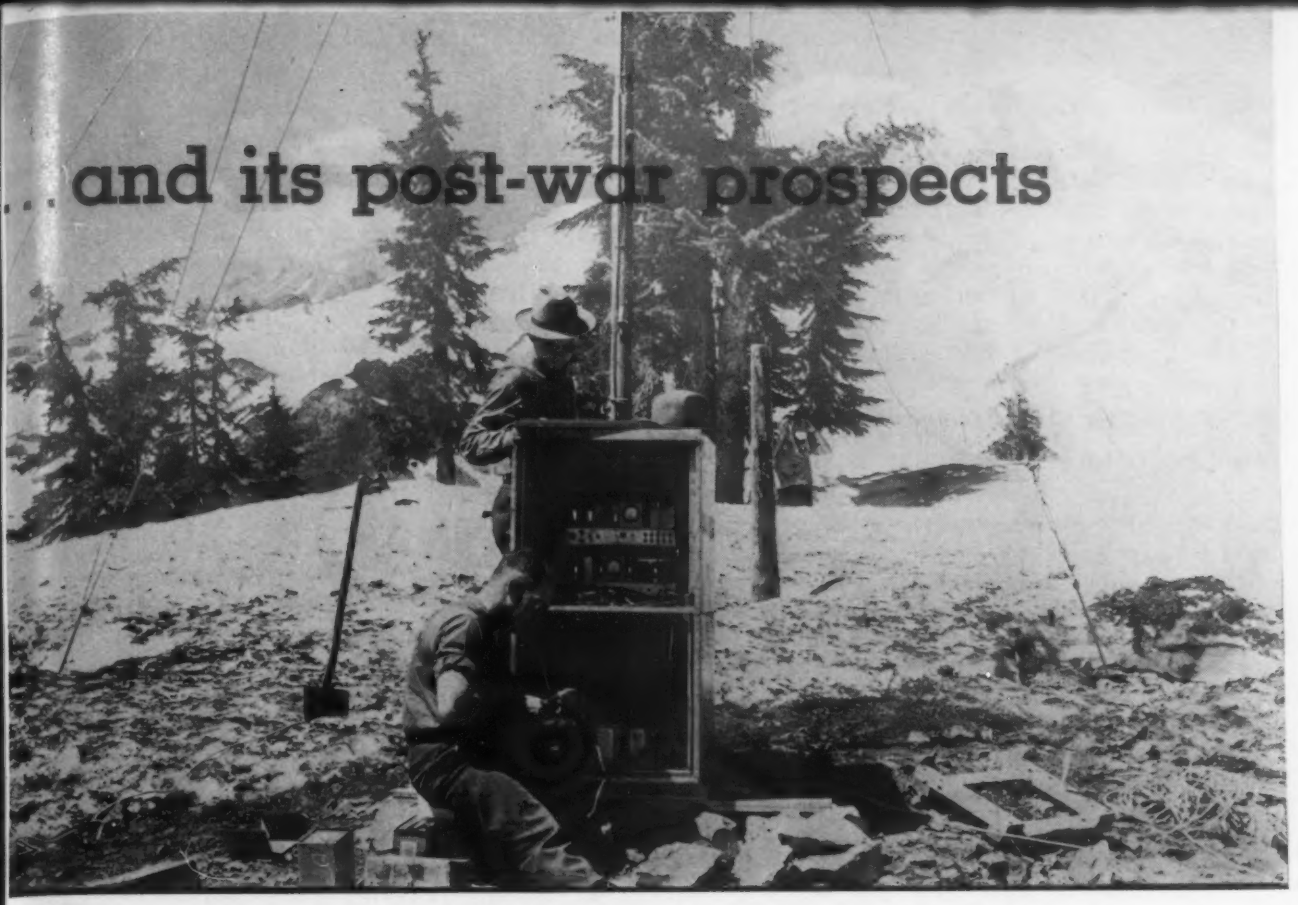
What Has Radio to Offer Today?

The United States is the center of highly efficient and flexible world-wide systems of international and marine point-to-point radio communication. The services of these systems, which early in the 1920's were shifted from long to short waves, included high-speed automatic radiotelegraphy, radiotelephony, radiophoto, radionavigation, or direction finding, and radio-safety.

Here, too, was the world's greatest application of radiotelephony to broadcasting as a means of mass communication. Some 55,000,000 radio receivers were in the homes of Americans, served by more than 900 radio stations scattered throughout the country. Linking the majority of these stations were four national broadcasting networks, providing outstanding services of entertainment, education, news and information.

Less apparent, but equally vital, were the domestic services of point-to-point radiotelegraphy and radiotelephony. These included commercial message traffic, commercial aviation, police and fire work, highway traffic control, forestry, and other interests requiring a high degree of communication.

. . . and its post-war prospects



FOREST SERVICE — All radio is not broadcasting entertainment or news or educational programs. Much use is made of modern "wireless" for communication between ships at sea, between airplane and land, in the police, forest, fire and other services where no other means of communication can serve as well

Just beginning was the new service of television, adding radio sight to broadcast sound. Regular television program schedules had been started in New York, and plans for similar services in many other large cities of the country were afoot. Manufacturers were ready to build and sell home television receivers to the public. Means of establishing inter-city television networks by either coaxial cable or radio relay systems had been developed.

Concurrent with the development of television was the opening of still another portion of the radio wave spectrum—ultra-short waves. This not only made room for the services of television, but also enabled the application of frequency modulation to sound broadcasting. Just beginning, also, was the broad development and application of radio-electronic principles to non-communication purposes, for example to industry and to research.

Behind all these services of radio was a vast industry, employing more than 500,000 persons and doing a yearly business in excess of $1,000,000,000.

Immediately after the Japanese attack on Pearl Harbor, the American radio industry began converting from peace to war production, accomplishing the job in a few months.

It was well they did. Fortunate, too, was the fact that American industry had developed and expanded radio to a point unequalled by any other nation; for modern warfare, especially when fought on a vast global scale such as this one is, requires a type of fast, flexible communication that only radio can supply.

War calls for stronger, sturdier, more dependable instruments than we use in peace-time, and it requires that we develop new devices and new services. We are meeting this demand today in our laboratories, our engineering workshops, and in our manufacturing plants.

War Accelerates Scientific Development

Until the war is won, much of what is being done must remain a military secret. It can be said, however, that under the force of urgent necessity, we are making rapid advances in the development of new electronic tubes and in the design of radio circuits. New areas of the

TWO YEARS OF FM

Broadcasting has always thrived on new ideas. What post-war radio may do for American industry may be gleaned from a two-year record of frequency modulation.

In two years, the number of stations grew from one to 45 regularly on the air, with a total of at least 125 signifying interest. Between 500,000 and 600,000 receivers were sold and placed in service. At present there are perhaps 40 million people who could be adequately covered with FM if the transmitters were available.

radio spectrum are being opened. Prior to Pearl Harbor, we had made a good start with ultra-short waves, measured in lengths of 10 meters or less, and were beginning to use microwaves of 40 to 60 centimeters in relay systems. It can be expected that research now being done will open for use wavelengths of 1 to 3 centimeters.

What Will Post-War Radio Offer?

What, then, can be expected of radio in the post-war period? It is impossible, especially at present, to be exact in predicting what is to come. On the other hand, some of the possibilities can be indicated in general terms.

Broadcasting. New methods and new radio-electronic devices will greatly improve the quality of reception on broadcast frequencies.

There should be greater use in broadcasting of ultra-short waves. Because of the nature of these frequencies, it is possible to use modulation methods and systems which not only improve the quality of reception, but also reduce atmospheric and other noise.

Greater use of the ultra-short waves through continued expansion of frequency modulation and television will bring about, in the years to come, some readjustment in sound broadcasting. Sound broadcasting, however, will retain considerable importance even after television is established on a wide scale.

In the field of international short-wave broadcasting, we may look forward to a much higher degree of technical perfection. The time is coming when this type of broadcasting will have a quality comparable to the best in domestic broadcasting. Improvements are coming in both short-wave transmitting and receiving instruments. Moreover, we are rapidly accumulating new knowledge of the "space circuit," or the behavior of radio waves in the atmosphere.

Television. One of the most fascinating prospects is offered by television. More sensitive cameras will be capable of operating indoors as well as out; images will be brighter, bigger and clearer; transmitters will be linked by intercity networks; three-dimensional and color television are well within the long-range view. I know of nothing that will give such a broad range of employment as the introduction of this new art on a wide scale.*

International Communication. As is the case with international short-wave broadcasting, transoceanic point-to-point radiotelegraphy will be greatly enhanced. Improved circuits and electronic devices, together with the increased knowledge of "space circuits," will heighten efficiency and quality.

We may expect an added number of transmitting channels to become available, especially for code. For one thing, there should be a more efficient use of the available frequencies. More channels of information will be put into a given frequency space. Better directional and "steerable" antennas will improve both voice and code transmissions. More sensitive receiving devices will permit the use of less power.

Methods for transmitting large quantities of information, such as facsimile, possibly will find application on the international circuits.

Multiplex transmissions, automatic and error-proof printers, and voice and code "scrambling" devices, which will improve the secrecy of radio circuits, should come into greater use.

Marine radio will benefit much in the same manner as international communications.

Domestic Communications. On the domestic scene, there is the possibility of radio relay networks being established to carry from

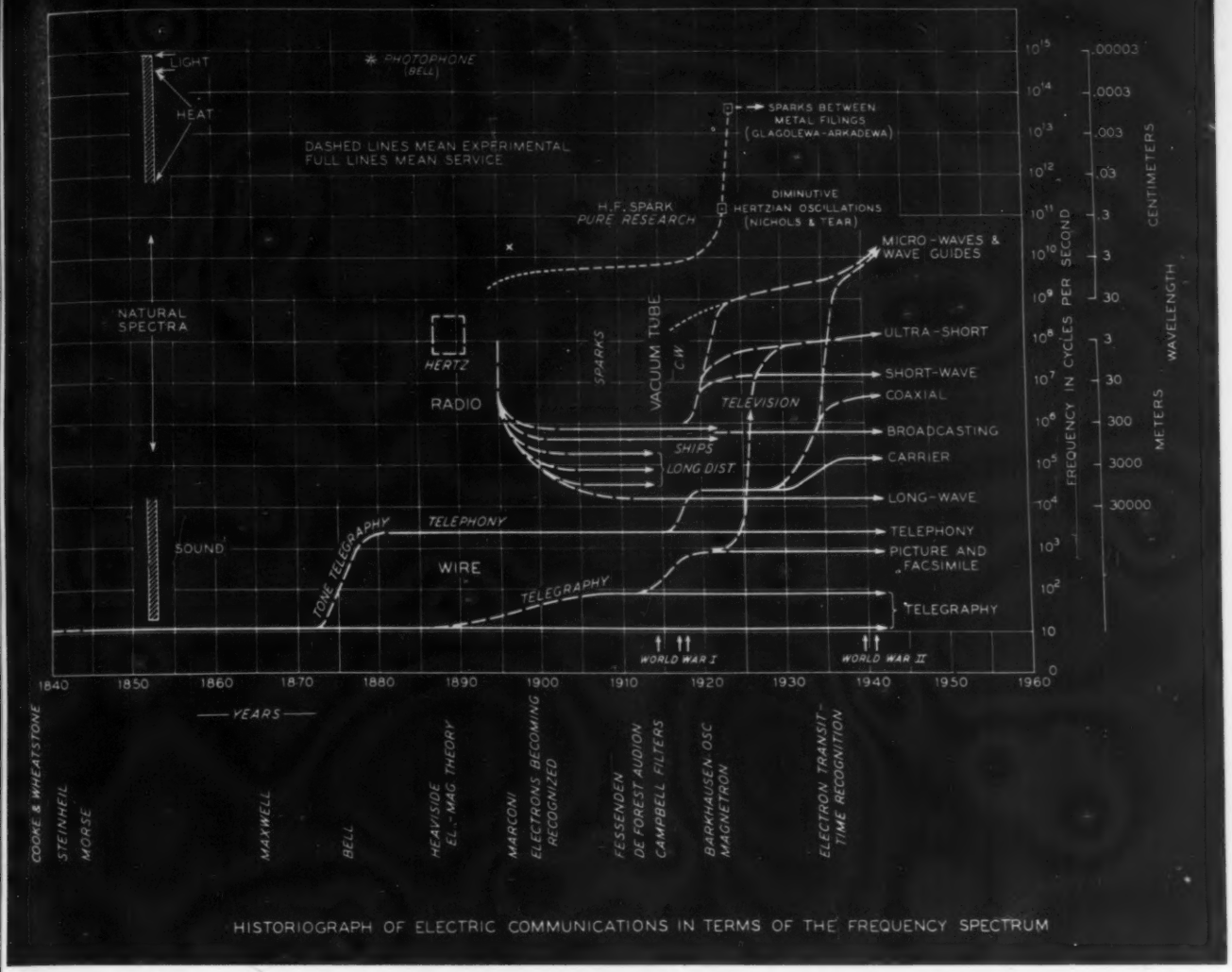
* Editor's Note. Mr. Beal's survey on television has been shortened since his opinions parallel those of Mr. Shelby to be found in the section to follow.

RADIO STATIONS IN THE UNITED STATES

June 30, 1941 ‡

Alaskan Service	
Fixed Public	321
Experimental	2
Special Emergency	6
Aviation	112
Coastal	159
Subtotal	600
Aviation	
Aeronautical	438
Aeronautical fixed	210
Aircraft	2,140
Airport	75
Flying School	25
Subtotal	2,888
Broadcast*	
Standard Broadcast	897
H-f Broadcast	69
Low-frequency Relay	229
High-frequency Relay	269
Developmental	8
Television	47
International	12
Facsimile	4
Studio Transmitter (S.T.)	4
Non-commercial Educational	5
Experimental	1
Subtotal	1,545
Coastal Service	
Marine Relay	37
Coastal Telegraph	52
Coastal Harbor	32
Coastal Telephone	4
Limited Gov't Service	3
Subtotal	128
Emergency Service	
Municipal Police	1,196
State Police	513
Zone Police	69
Interzone Police	30
Special Emergency	340
Forestry	807
Marine Fire	6
Subtotal	2,961
Experimental	
Class 1	216
Class 2	231
Class 3	1
Subtotal	448
Miscellaneous Service	
Geological	269
Motion Picture	12
Provisional	7
Mobile Press	4
Relay Press	7
Subtotal	299
Point-to-Point Telegraph	
Public	69
Press	3
Agriculture	7
Subtotal	79
Point-to-Point Telephone	
Public	15
Ship Service	5,214
Grand Total	14,177

*July 1, 1941. ‡FCC Seventh Annual Report to Congress, June 30, 1941.



Chronological extension of frequency bands for communication (Espenschied)

city to city the services of television, sound-broadcasting, high-speed facsimile, message printers, and other forms of communication in voice and of record. This development may occur in parallel with the growth of similar services by coaxial cable and by wave guides.

There should be an expansion of the use by aviation and the railroads of radio as an important aid to the movement and control of traffic. An example of a possible application in this line would be a "radio traffic chart," which would show, from moment to moment, the exact location of trains in motion on the ground or airplanes in the sky.

Aviation radio, already highly developed, will show vast improvement. Services of both voice and code communication will be more widely applied. Radio-electronic devices will aid navigation through the ability of a plane to locate itself automatically anywhere in flight. They will be used to guide and land planes blindly, and to avoid collisions in the air and on the ground. Television and television techniques will enable airplanes to "see" through fog.

In fact, we may expect radio to become, to an astounding degree, the "eyes," "voice," "ears," and "feelers," of all mobile craft.

A broad expansion of radio's services in the specialized fields of police and fire work, forestry and safety can be readily foreseen.

Studies of the space circuits traveled by radio signals, more sensitive receiving devices which require less transmitting power, ultrahigh frequencies and microwaves, radio facsimile and television—all should find extensive applications in the problems of community service.

Greater use of radio in the control of motor highway traffic seems probable. An outstanding example of this type of service is the ultra-high frequency radio system of control on the Pennsylvania Turnpike.

Television could be widely used in police, fire and forestry work, providing instantaneous visual communication where it is desirable.

The Micro-wave Region

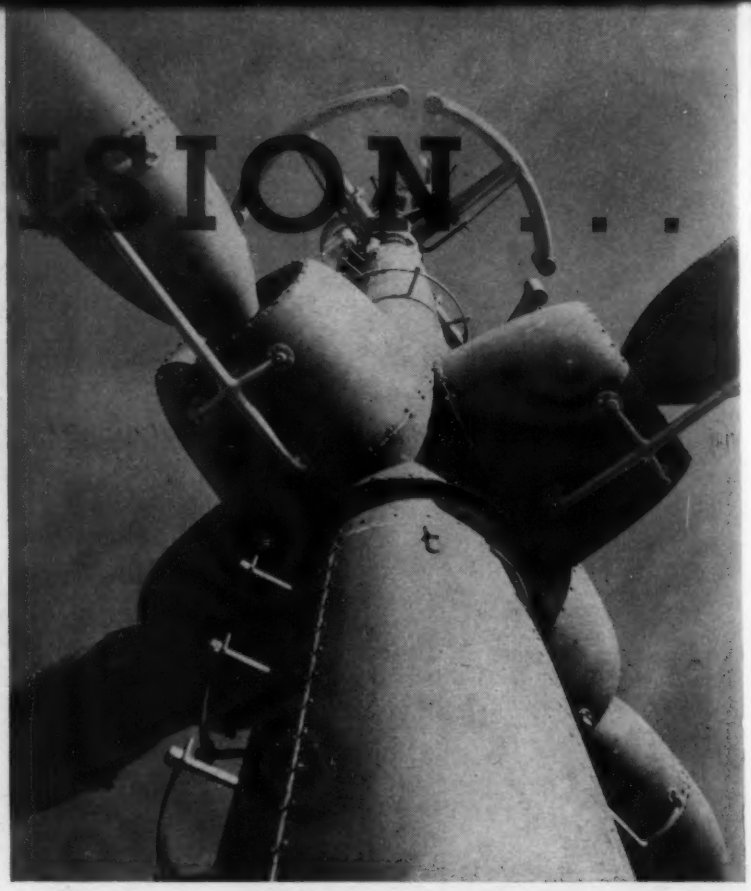
Further development of radio in the micro-wave field will make available some services which now seem fantastic. These would include the possibility of a motorist, while traveling on a highway, dialing a telephone number and talking to home or office without stopping his car. Passengers on moving trains might have the same advantage. In the more distant future, enough wavelengths may be available to permit pedestrians to carry personal radio-telephones. It is probable that such services as these would tie into the regular wire-line systems through special radio stations located at intervals along streets and highways.

Non-communication Applications. In recent years, many of the principles of radio-electronics have been applied to fields other than communications. Radio tubes have been

(*Continued on page* 176)

TELEVISION . . .

By ROBERT E. SHELBY
Development Engineer,
National Broadcasting Company



ANTENNA—Looking toward the top of the television antenna on the Empire State Building, New York City. The peculiar shape of these antenna elements arises from two desires—to transmit a wide band and to concentrate radiation in the horizontal plane

THE scientific concepts of television are not new as judged in relation to the pace of modern engineering developments, but it has been only within the last 15 years that rapid progress in the field of electronics has made possible the development of a television system adequate for a commercial service. During this period the electronics art and the television art have been extensively interlocked, many electronic developments having resulted directly or indirectly from the search for better television. Modern television is electronic television, and the electronics art in turn owes much to television.

The television principle of breaking a picture up into elementary areas and transmitting the information in sequence to a distant point where the scene is re-assembled, was suggested in 1884 by Nipkow.

This operation is necessary because the electrical circuits and the radio channel associated with the television system are incapable of transmitting at once all of the information contained in the usual scene. Instead, this information is sent for one elementary area at a time, the scanning rate being made high enough so that many complete pictures are transmitted in a second (30 per second is standard), and the eye, due to the phenomenon of persistence of vision, sees a complete picture on the reproducing screen in spite of the fact that only an elementary area is actually being presented at any given instant.

Early Television Depended Upon Mechanics

The first method utilized to achieve this picture analysis and synthesis involved the use of a mechanically rotated scanning disc, consisting of a circular sheet of metal with a series of spirally located holes near the edge of the disc. It operated by causing a small spot of light to fall in sequence on each elementary area of scene being televised. The light reflected from each area was gathered by one or more photocells. Then, as each unit area of the subject scene was illuminated in order, the output of the photocell varied to control or modulate a light source at a receiving point. Since the light source at the receiver varied in accordance with the variations in reflected light from the scene being televised, it was then only necessary to provide a similar scanning disc at the receiving point running in synchronism with the disc at the pickup point and the original picture would be reproduced.

This mechanically operated scanning system had fundamental limitations and disadvantages. To give high definition in the reproduced picture, the scanning discs became prohibitively large. To provide a high repetition rate for the complete picture in order to allow smooth motion in the reproduced scene and eliminate visible flicker, the peripheral speed of the scanning discs had to be unreasonably high. Synchronizing was a problem, as was the noise of the large rotating disc.

Electronic Scanning Overcomes Inertia of Mechanical Systems

The limitations of a mechanical television system were soon recognized and experimenters cast about for some scanning device possessing lower inertia which would permit the desired higher rates of scanning. It was inevitable that their attention would turn to a consideration of the possible use of the electron—smallest particle of matter, possessing an inertia even at high velocity which is negligible in relation to television scanning requirements. An electronic device for use on the receiving end was already available in a crude form. This was the Braun tube, consisting of an evacuated envelope, a fluorescent screen and a set of electrodes to direct a stream of electrons (cathode-ray) against the fluorescent screen.

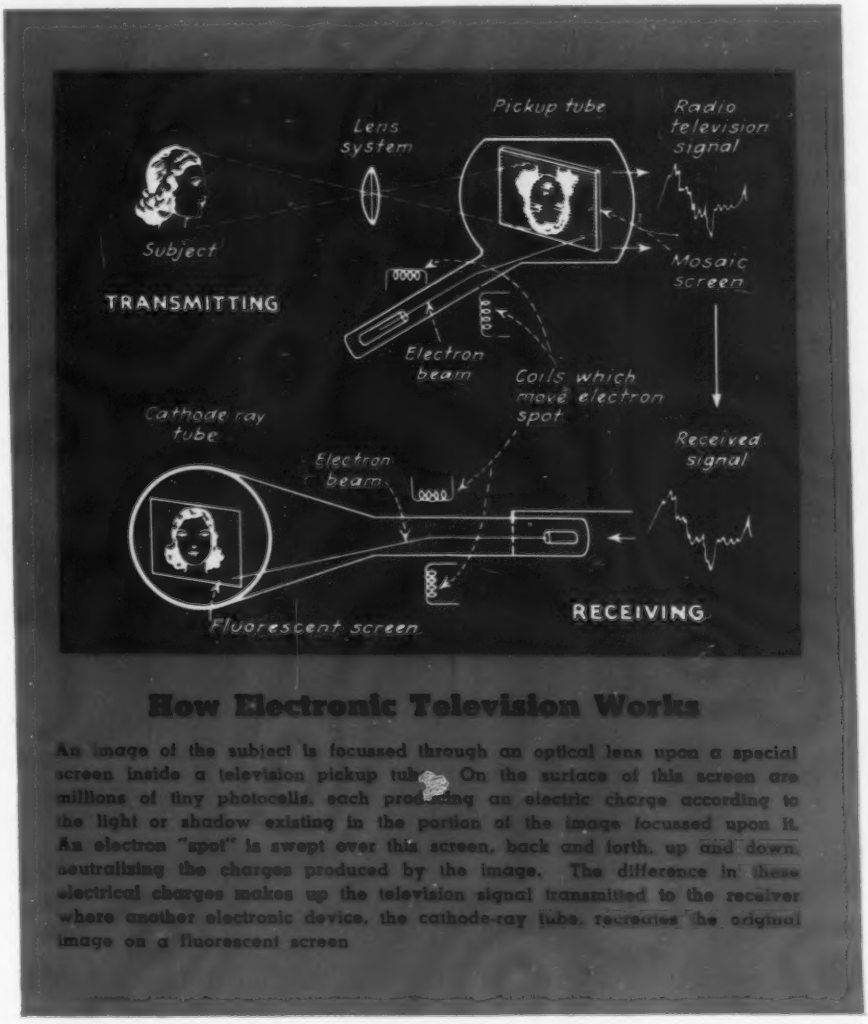
Far-seeing Eye of the Future

On July 1, 1941, television became a commercial broadcasting service in this country after many vicissitudes. Except in a few outstanding laboratories and studios, however, television has since become another casualty of the war. All this will change the day peace comes

The modern television kinescope , however, a highly refined version f the early Braun tube, special feaures having been added to provide harp focus of the cathode ray (i.e., mall scanning spot), high light outut, white light from the screen. he extended research work from hich these refinements were evolved ontributed much to the electronics rt. For example, development of he field of electron optics, which toay rivals in importance the much lder one of light optics, received its reatest impetus from the search or a sharply-focussed high-intensty beam of electrons for television canning devices.

The situation with respect to an ll-electronic pick-up device for teleision was very different from that or the reproducer. No device was nown in the previous art which ould reverse the process of the Braun tube. This very fact, however, erved to stimulate the imaginations f early workers in the field and it s interesting to note that as long go as 1911, A. A. Campbell-Swinton n England proposed a method for btaining all-electronic television ick-up. In many respects his proosal visualized present day systems lthough it lacked the important actor of storage of the electric harge between successive scannings —the principle that would give the ll-electronic pick-up device the ensitivity to make it practical with igh definition scanning. This early roposal of an all-electronic televiion pick-up device was not reduced o practice. Further development as necessary before necessary electronic tools and techniques were vailable for all-electronic television.

In 1923, V. K. Zworykin applied or patents on his Iconoscope—a cathode-ray television camera tube having inherently greater sensitivity than any previously proposed by virtue of its property of accumulating, over relatively long periods of time, the electric charges resulting from photo-electric emission. The Iconoscope or modifications of it are now used in a majority of all modern television cameras. It consists essentially of a mosaic (light-sensitive plate) and an electron gun, assembled in a highly evacuated glass envelop. The gun is an electron-optical system serving to produce a fine stream of electrons (cathode-ray) which is made to scan the sensitive surface of the mosaic by means of suitably varying magnetic fields produced by coils placed around the



How Electronic Television Works

An image of the subject is focussed through an optical lens upon a special screen inside a television pickup tube. On the surface of this screen are millions of tiny photocells, each producing an electric charge according to the light or shadow existing in the portion of the image focussed upon it. An electron "spot" is swept over this screen, back and forth, up and down, neutralizing the charges produced by the image. The difference in these electrical charges makes up the television signal transmitted to the receiver where another electronic device, the cathode-ray tube, recreates the original image on a fluorescent screen

neck of the tube. The mosaic consists of a thin sheet of mica covered on one side with hundreds of thousands of separate minute particles of silver which have been sensitized so that they give off electrons when light falls upon them. On the other side of the mica sheet is a solid metallic coating, to which the signal is transferred by capacitance from the sensitive elements on the front side, and from which the signal currents pass to the external circuit.

Iconoscope Stores up Charges Produced by Cathode Rays

Briefly, Iconoscope performance is as follows: The light image of the scene to be televised is focussed by means of a lens onto the light-sensitive side of the mosaic, and each element of the mosaic, due to photo-emission of electrons, accumulates an electrical charge corresponding to the brightness of that portion of the scene focussed upon it. The cathode-ray scanning beam from the electron gun sweeps across the mosaic in a series of parallel lines, releasing the charge on each element of the mosaic and thereby generating electrical signal currents in the circuit connected to the signal plate.

In the early 1930's, P. T. Farnsworth, with his Dissector* tube and V. K. Zworykin, with the Iconoscope, demonstrated television systems of fairly good definition based exclusively on electronic scanning. By 1936, the all-electronic method, responding to the demand for television images of higher and higher definition had so far out-distanced mechanical scanning methods that the prominent experimenters in the field discarded mechanical scanning entirely except in a few instances for the televising of film. Since 1936 the accelerated progress in the field of television has involved refinements in apparatus and techniques and an improvement in picture resolution, culminating in the 525-line 30-frame interlaced images which were established commercially on July 1, 1941.

Post-War Television

There seems to be little doubt that television broadcasting will advance at a rapid rate as soon as the war ends. Many of the principles discovered and the developments which were advanced in the progress of the television art are finding important application in the war effort.

In venturing predictions concerning the future of television, it is worthwhile to study the history of similar industries which are further advanced. We might, for example, compare the fields of television and motion pictures. We would then find that radio broadcasting is now at a stage in its development corresponding to that of the motion picture industry at the time of the public introduction of the talking movie about 1926, except that the changes in the two cases are reversed. In radio broadcasting, we are just now adding sight to sound, commercially, whereas in the motion picture industry in 1926, sound was just being added to sight, commercially. When we consider the fact that sight is unquestionably a more important human sense than sound, it seems reasonable to anticipate that this metamorphosis which is about to take place in broadcasting will be even more important than the one which the motion picture industry went through in the years between 1926 and 1930.

In the development of both the motion picture and sound broadcasting industries, means had to be found for syndication of entertainment features. In the motion picture industry this was achieved by providing hundreds of duplicates of a single feature film and distributing them to the thousands of theatres throughout the country. In sound broadcasting, syndication was first achieved by interconnecting broadcasting stations throughout the country by means of wire circuits so that a single program might be broadcast simultaneously by all stations so interconnected. In both cases, the tremendous advantage gained was the low program cost per unit of audience, making possible expenditures of large amounts on single entertainment features which would be out of the question economically without syndication. Unquestionably syndication will be required in television for the same reason, as well as for the reason that immediacy will be extremely important in many television programs just as it is in sound broadcasting.

The network interconnection of television broadcasting stations presents a new problem requiring special solution. In the case of sound broadcasting, network interconnec-

* The Dissector tube is an all-electronic pickup device in which a picture of the image is made up of electrons which are caused to pass through a narrow aperture in sequence. It is most useful in televising motion picture film.

OCD—Outdoor television pickup of one lesson in a series produced by National Broadcasting Company for civilian defense personnel training

PROGRESS—Three pictures taken from a television receiver screen, showing progress since scanning-disc days. In order, 60-line, 120-line and the present standard 525-line pictures

tion is possible by the use of facilities already in existence but, generally speaking, no such facilities which might be used for television network connection exist. A considerable amount of work has been done on this problem, however, and two technically satisfactory solutions have been found. One is transmission of television programs from station-to-station by means of special cables capable of transmitting the wide band of frequencies required by television signals. This method has been developed by the American Telephone and Telegraph Company and has been demonstrated by them on several occasions. An outstanding example of the use of such special facilities was the televising of the Republican National Convention by NBC in Philadelphia in the summer of 1940 and its transmission to New York by means of an experimental coaxial cable of the A.T. & T.

The other method of interconnecting television broadcasting stations for network operation is by means of radio relay circuits. Extensive experiments along these lines have been conducted by RCA Communications (RCAC) and facilities involving the use of three radio relay stations for the transmission of a television program over the NBC station in New York showed that this method would also solve the problem satisfactorily.

Lower Cost, Longer Pictures, Color, Stereo are all Post-war Possibilities

As regards post-war television receivers for the home, it is to be expected that prices will be lower than before the war. This will be due not only to the economies resulting from mass production but also to the adoption of production techniques and facilities developed for manufacturing special equipment for the war program. The projection-type reproducer seems likely to be widely used for all except the lowest-priced sets, since it has already been demonstrated successfully. It is to be expected that a single piece of furniture for the home providing television, sound broadcast reception (FM and all-wave AM), phonograph, and possibly facsimile, will make its appearance. Employing the projection principle, the better home television receivers will provide pictures ranging up to 2 or 3 feet in size.

Again paralleling the history of the motion picture industry, television probably will add reproduction in color as motion pictures in natural color have come as a refinement to motion pictures in monochrome. Whether these television pictures in natural color can be added in the existing wave bands provided for monochrome television, or will come as a new service in other radio channels, remains to be seen. Experimentation with color television has been actively under way for some time and was receiving increased attention when we entered the war.

Stereoscopic or apparent three-dimensional television pictures theoretically are possible and have been experimentally demonstrated—in natural color in at least one case. It now appears less likely that stereoscopic television will come into widespread use than that color television will be available. Again, we find here a parallel between the motion picture field and television. Stereoscopic motion pictures have been demonstrated spasmodically for a number of years. The need for special viewing equipment or restrictions as to position for the audience in both cases put the stereoscopic process at a distinct disadvantage and the amount of added realism, so far at least, does not appear to justify the effort. This situation might be summed up by stating that if there is a real demand for stereoscopic television it probably can be provided, using basic principles already known.

Frequency modulation is a development in the radio field which has received a great deal of attention in recent years. This method of modulation has been standardized for the audio channel associated with television broadcasting stations, which makes it consistent with UHF broadcasting in the channels between 40 and 50 megacycles. Frequency modulation for video (sight) transmission also has been tested experimentally and this form of modulation was used in the radio relay circuit demonstrated by RCAC and referred to above. Thus, it is seen that this form of modulation is being given careful consideration for use in television. It would seem at the present time that FM is not likely to be used for broadcasting the video signal because of channel width limitations now imposed and difficulties encountered due to multi-path transmission, but it would be hazardous to guess what the future will bring on still higher carrier frequencies.

No discussion of television would be complete without consideration of

(*Continued on page* 178)

Military Communications . . .

By Lt. Col. C. J. McINTYRE
Headquarters, Services of Supply, Office of the Chief Signal Officer, U. S. Army Signal Corps

COORDINATION—Tanks on the ground and planes in the air are in constant radio contact with each other and with headquarters

IT is difficult to imagine military operations across the vast global distances of the present war being carried out, or even adequately planned, without the facilities of instantaneous communication made possible by the electron tube and all the radio apparatus that has been built upon and around it. The Signal Corps, the agency of the Army which procures all communication apparatus and coordinates its tactical use, is ever conscious of the significant contribution of electronic science to the tools which are used in modern war.

Communications have always been a matter of prime concern to the military commander. The factors which distinguish modern war from the campaigns recorded in history are greatly multiplied fire-power, armor, mobility and communications. All military leaders from the most ancient times until a century ago had to rely for communication on couriers afoot or mounted and on such visual signals as beacon fires and flags. Napoleon improved upon the visual signal system by employing Galileo's invention, the telescope, in a chain of semaphore stations to form what was then known as a "telegraph." It remained for the American Civil War, in which the Signal Corps had its baptism of fire, for the electric telegraph to prove itself in a major role as an instrument of military communication. The pioneering discoveries and inventions in electricity were made in the nineteenth century, and they gave us telegraphy and telephony. The great discoveries in electronics in the twentieth century have given us the art of radio communication. This had its military try-out in the first World War and has affected in many ways the strategic and tactical maneuvers which are being used in the present conflict.

Radio plays a crucial role in coordinating our operations in this

DIRECTION—Nerve centers of operations are headquarters set-ups such as this protected from bombs yet with electronic fingers on every pulse

their part in GLOBAL WAR

The contributions of electronics to our war effort have been many. Without some of them, it is difficult to see how current gigantic operations could be planned and executed at all. Tubes, too, are proving themselves indispensable for non-communications purposes

global war at every stage of the way, from the powerful fixed transmitters of the War Department Signal Center in Washington to the man on the front line reporting the effects of artillery fire over his back-transported walkie-talkie, and to the bomber winging hundreds of miles beyond the enemy's lines. At every stage of the way, armies of electrons pulsating between cathodes and anodes of evacuated tubes, setting up magnetic fields in coils and electric fields in the dielectric of capacitors, serve to speed onward vital messages of military importance to the men waiting upon them for the signal to action.

Army Signal Service Appropriations by Congress

Fiscal Years Ended June 30	
1930	$ 8,224,900
1940	18,236,618
1941	170,875,362
1942	3,723,604,696
1943*	2,617,506,025

*Exclusive of supplemental appropriations

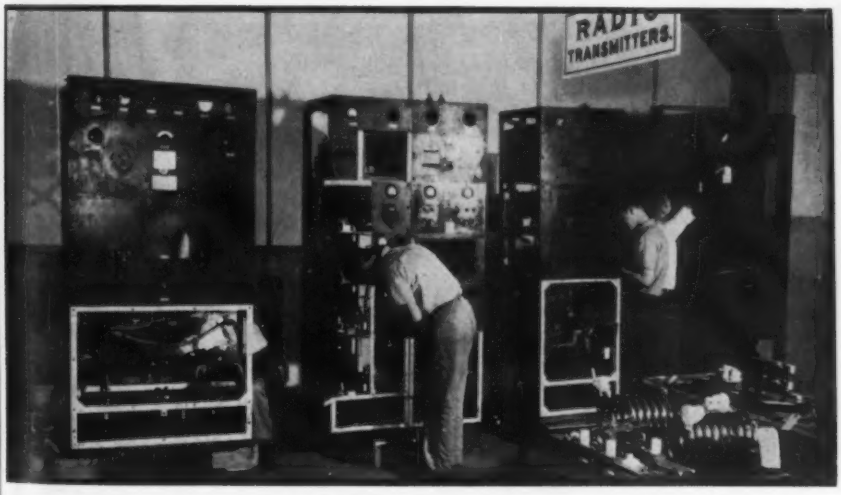
The above figures cover, of course, much more than purchases of electronic gear, including the training and clothing and housing of a number of Signal Corps troops larger than the entire United States Army in 1939. The Signal Corps is, however, procuring radio and electronic equipment for the Army alone at a rate greater than the entire production of the industry for all purposes in peacetime years

Signal Center, War Department's Hub of Communication Network

The focal point for all communications between the War Department and its task forces in all continents is the War Department Signal Center in Washington. By means of numerous radio networks, messages are sent to and received from all major domestic installations of the Army and the headquarters of all overseas commands.

The War Department Signal Center provides for communication by both wire and radio. The radio section is known as Station WAR, although actually it consists of a number of stations operating on different frequencies and directionally beamed to different parts of the world. Among the distinguishing features of the War Department Signal Center is the high degree of flexibility in the interconnection of equipment to different circuits and the extensive use of high-speed automatic transmitting equipment, not only for wire communication but also for radio communication. This makes it possible to carry a greatly increased volume of traffic for a given number of wires or radio channels.

If we follow a directionally beamed radio wave from the War Department Signal Center to a particular theater of operations, we would find that the distant station on the main War Department radio



MAINTENANCE—Signal Corps men with thorough training keep equipment in repair, in the field at centralized bases

MOBILITY—"Walkie-Talkies" of many types are used by the Army, Airforce and Navy. Here a paratroop Major demonstrates to British Commando chief Lord Mountbatten while our own General George C. Marshall looks on

net becomes in turn the control station of another net which serves the needs of the commanding general of that theater. Whenever a unit or combat team goes into action, smaller radio networks are set up, linking the radio transmitters and receivers housed within its vehicles, in its aircraft and at its stationary command posts.

The Army uses the term "net" in preference to the broadcasting terminology "network." The radio net for tactical purposes consists of two or more transmitters and receivers. A single net may include sets both on the air and on the ground, both stationary and in motion. Usually each net has a net control station which is in turn a secondary station in a larger net serving the next higher unit of the Army. Tactical radio nets vary greatly in accordance with their purpose.

An interesting feature of a tactical radio net, from the standpoint of the engineer, is that the traffic load actually carried may be quite small compared with its message-carrying capacity. This results from the military consideration that the best operated field radio net is usually the one which is least overheard by the enemy intelligence. The value of a radio set in an area of active operations is measured not by the number or length of the messages sent over it, but rather by the importance of those messages which are sent. A single message—an order from a command post, a report from a forward observer—may often mean the difference between success and failure of a skirmish, a battle, or a campaign. This means that the Army, by comparison with commercial communications networks, has had to put an enormous capital investment into its communications system. Every communications line must be duplicated, if possible, both by wire and by radio, for there must always be, regardless of possible destruction of equipment by enemy action, an alternative method of getting the message through.

Communications for Mobile Forces

The most spectacular use of radio communication in active combat occurs in the Air Forces and in the Armored Force. There are quite a few similarities, as far as communications are concerned, between the operation of bombers and fighters in the air and the operation of tanks and tank-destroyers on the ground. In both cases the vehicles have cut loose entirely from wire communication and must depend exclusively (except for short range visual signals) on their radio sets. In both cases, the noise conditions are such that members of the same crew talk to each other by means of an electrical interphone system. Every combat tank and airplane, therefore, is equipped with two or more complete communication sets, in which electronic tubes play an important part.

Because of the speed and stress at which men must carry on their duties in airplanes and tanks, their radio equipment must be of such a design that it can be worked with the utmost ease and simplicity. The newest tank radio sets are designed to eliminate the twisting of dials. Their channels, crystal-controlled, are pre-set and are selected by simply pushing a button.

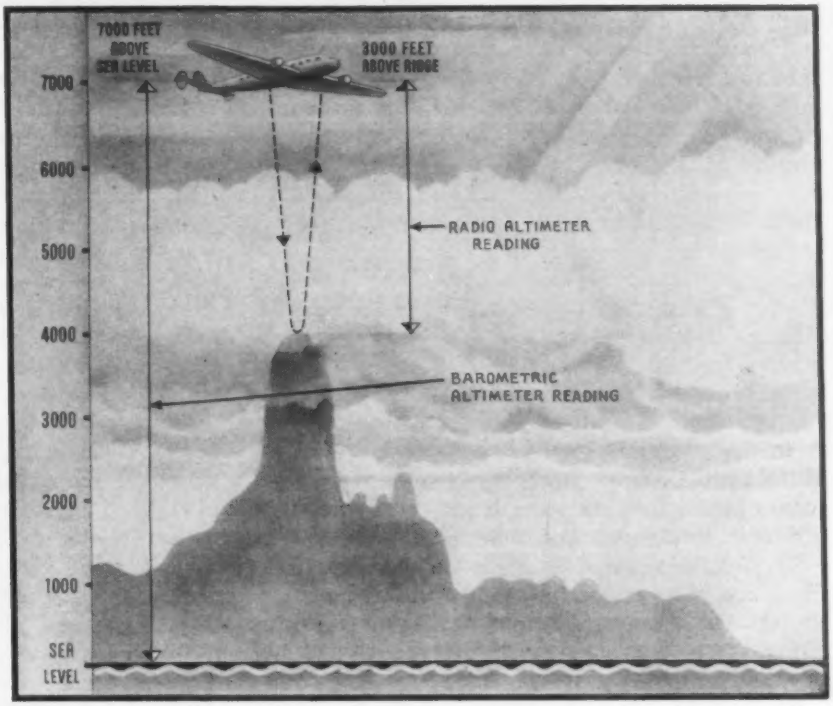
Great pains must be taken in advance to guard against the effects of all types of interference—the impairment of reception by atmospherics, by unwanted signals and by the effects of electrical apparatus or machinery. To take fullest advantage of the most recent developments of electronic science in reducing the effects of interference, frequency-modulation has been adopted for use in tanks, tank destroyers and the Field Artillery.

A complete radio system was put into effect during 1942 for tanks and tank destroyers, permitting short-range communication between tank commanders and the individual tanks under their control. Each tank is equipped with two-way short-wave radio, frequency-modulated and crystal-controlled. The tank carrying the commander of a tactical unit will have two complete radio systems, over one of which he communicates with the men under his command, while the other serves him for communication with the commander of the next higher echelon. Thus, the principal and subordinate radio nets are interlinked to provide continuity in the flow of orders and information even during the heat of a mechanized encounter. The radio system for the armored force includes smaller sets for reconnaissance use which can operate on the same frequency with those in the tanks.

A similar system has been set up for the Field Artillery. The sets operate with frequency modulation on high-frequency channels which, again, are accurately calibrated by crystal control. Some of the sets

(*Continued on page* 180)

AVIGATION AIDS . . . promote flying safety



ABSOLUTE ALTIMETER—Old height indicators operated by barometric pressure merely showed altitude above sea level. New ones, operated by radio signals transmitted from and reflected back to the aircraft, show altitude above terrain. The small photo shows a typical Western Electric absolute altimeter antenna installed beneath a wing

BY LT. Col. P. C. SANDRETTO
U. S. Army Air Corps

WITH the development of simple directional antenna systems and the Bellini-Tosi goniometer, direction-finding systems were developed and applied to ships. Previous to the advent of these direction finders, boats navigated by the use of magnetic compasses and celestial methods. While it appears that the addition of a third method of navigation to the two previously employed should have been enthusiastically received by mariners, such was not always the case. The masters of the ships were not familiar with radio (or wireless as it was known in the early days) and, therefore, did not trust the bearings given by the radio equipment.

Because of the low sensitivity of the receiving equipment available at the time of installation of the first direction finders, the necessary range for the bearing-taking systems could best be obtained by the use of very large antennas. Such antennas could conveniently be installed only on shore.

Strange as it may seem to those familiar with radio, the use of shore installations was one of the factors that contributed largely to the unpopularity of radio navigation on boats. The captains argued, "How can people located at great distances from the boats know the location more accurately than the men on the boats?" This misunderstanding, together with the occasional poor bearings caused by the phenomenon, then not understood, of night effect, prevented confidence from being built up in radio navigation systems by the captains.

Vessels traveling at their usual slow speeds seldom have instant need for making positional determinations when on the high seas; thus it was not *absolutely* necessary that this navigational system be adopted by ships. The installation of direction finders on shipboard which allowed bearings to be taken quickly when the ships were near shore, under fog conditions, and in danger of going aground served to reverse the previous opinion of direction finding by the ships' masters, and radio navigation has since been a highly valued facility on every ship.

Aviation Added a Third Dimension

The advent of aviation brought forth a conveyance for traveling in a medium as unmarked as the sea, which added a third commonly traveled dimension. Further, the new conveyance travels at speeds greatly in excess of those maintained by ships at sea, and it was not possible to stop while the location was being

determined. Motion at all times had to be continued. Therefore, without exaggeration it can be said that the growth of aviation, and particularly air transportation, was made possible only by the development of radio avigational facilities.

Shortly after the last war, when commercial aviation service was inaugurated in Europe, the airplanes used were of the cabin type, seating more than one person; therefore, the method of avigation adopted followed shipboard practice. A radio operator was employed; he released a long, trailing wire antenna and used long waves to ask a ground station for a bearing. The ground station took the bearing on the airplane's transmission and reported back to the operator.

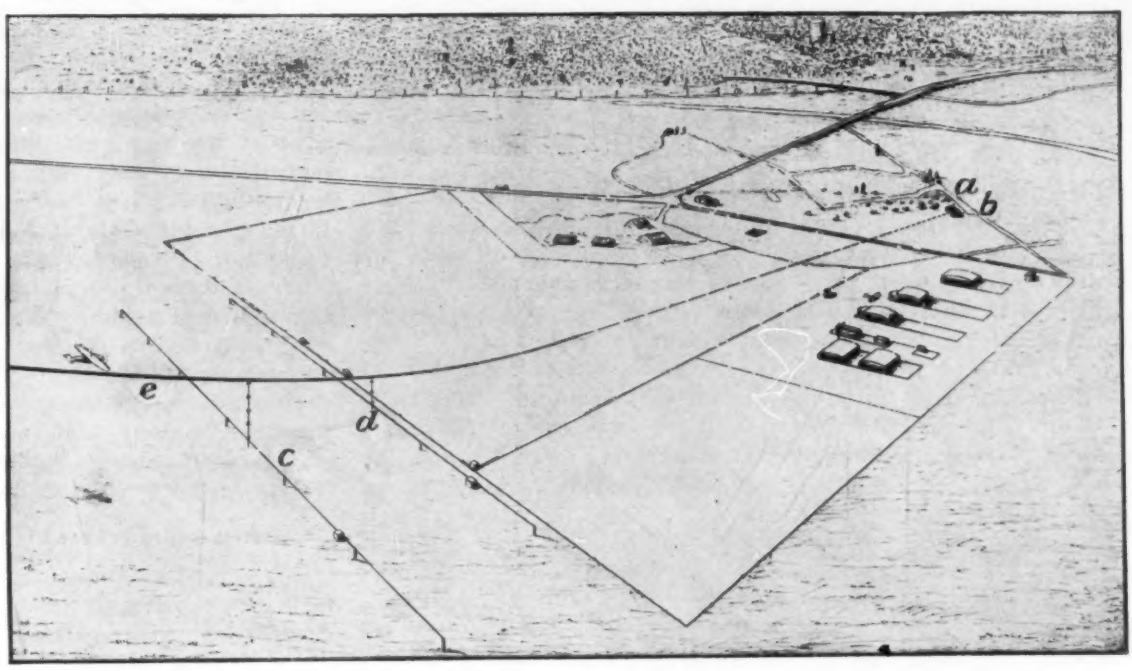
In the United States, however, the airplanes placed into use were of the single-seat type and intended mainly for carrying mail. In this type of airplane one pilot had to fly the airplane and do his own avigating; therefore, a more rapid and more nearly automatic avigation method was required. Such a method was devised by the United States Army and the Bureau of Standards in about 1927. This system consisted of a means for establishing in space a narrow radio beam. By means of a lightweight receiver, the pilot could follow this narrow radio beam to his destination. This system, then, was in fact a radio road which the pilot followed as he would a road on the ground; however, he used his ears rather than his eyes.

To employ radio waves with the most stable propagation characteristics known to the art, the long waves were used. Since it is difficult to obtain a sharp radio beam with long waves, the radio road was established by alternately making transmissions in two directions at right angles to each other. The directions actually followed were those where the signal strengths from the two directional beams were equal. By the use of this method, the radio road laid out had a width of approximately three degrees.

Considerable development of these radio roads has occurred since the initial work in 1927. The purpose of these developments was to secure freedom from certain effects, such as night error caused by transmission via the Heaviside layer, the addition of simultaneous voice transmission, etc. The United States Government maintains a chain of over 200 stations in the continental United States, operating in the band of from 200 to 400 kilocycles. The radio beams are shifted and bent to form connected airways which link together the principal cities throughout the entire United States.

Application of Ultrahigh Frequencies

Just before the outbreak of the present war, extensive development was undertaken by the Civil Aeronautics Administration and an experimental airway was established with a radio range system employing ultrahigh-frequency transmitters. The development decided upon for installation throughout the United States but which, of course, cannot be installed under the present conditions, presented in many respects a novel facility. This consisted of a radio range producing in effect a single beam which indicated on a visual meter. The pilot could tell whether he was to the right or to the left of this radio beam by noticing whether the needle on a meter indicated to the right or to the left. In addition, the pilot of an airplane could tell whether he was approaching the station or had al-



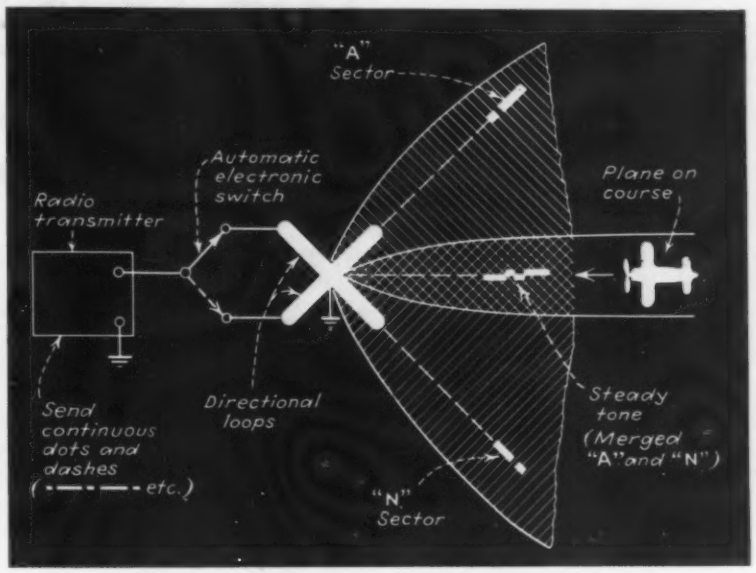
BLIND LANDING—After aural radio ranges guide aircraft to airports there is still the problem of getting down safely in bad weather. One method involves (a) a runway localizing beacon which sends up what might be called a vertical radio "wall" which lines approaching ships up on the runway, (b) a horizontal radio beam leaving the ground at a gentle angle, (c) an aproach marker radio signal and a similar boundary marker signal. Instruments operated by these beams guide the plane to earth over glide-path (e)

ready passed it by listening to an audible signal in his headphones.

The output of a radio receiver intended to receive these ultrahigh-frequency signals can be connected to the airplane's automatic pilot and, thus, automatically guide the airplane along the new type airway. The freedom from static which is enjoyed by the ultrahigh-frequency waves should provide an extremely excellent avigational facility for the after-the-war commercial transport.

It is often necessary for a pilot to leave an airway road in order to skirt a thunderstorm or to maneuver while waiting for permission to land. Therefore, it was realized that a direction finder on the airplane would be very valuable. Since the transmitters for the long-wave radio ranges were already installed on the ground, the aircraft direction finders were designed to operate from these facilities.

The first direction finders were manually-operated devices and, while they were of some help to the pilots, the necessity for turning a crank to operate them was an obvious disadvantage. The automatic aircraft direction finder with a needle which pointed to the radio stations on ground was placed in use in about 1938 and was greeted with great enthusiasm by the flyers. With this device it is necessary only to tune the receiver to the desired station; the needle on the dial then points to the station, and bearings are read directly. These direction finders employ a small loop about 10 inches in diameter protruding from the airplane. The total weight of equipment is rather heavy (about 65 lbs), but the facility provided by this device is considered to outweigh this disadvantage. With such an instrument it is possible to fly anywhere in the United States without reference to the established airways.



RADIO ROAD

Elementary explanation of aural radio range: Transmitter sends continuous succession of dots and dashes. Automatic electronic switch is timed so that dot-dash sequences forming code letter "A" go to one directional loop while dash-dot sequences forming code letter "N" go to other directional loop. Pilot approaching on proper course, in sector where signals from both loops overlap, hears steady tone due to merger of "A" and "N". Divergence from course causes one letter or the other to predominate

Direction Finders on Ground

Because the lower frequencies had been allocated for use by radio ranges, they could not be used for transmission on the airplanes. The medium-high frequencies were more suitable for communication but were not eminently satisfactory for direction finding. Only comparatively recently did direction finders for ionosphere-propagated waves become commercially available for use on the ground for taking bearings on the transmission from airplanes. The question naturally arises as to the necessity of taking bearings on airplanes from the ground when all of the other facilities are available to the airplane. The reason lies in the trend toward giving the men on the ground greater control of the flights. There have been several instances in the past when assistance from the ground helped to avert accidents. The Civil Aeronautics Administration made several experimental installations of these direction finders and some of the airlines had plans for several installations. Plans have been suggested for a nationwide network to be Government installed and operated; however, these plans have all been held in abeyance for the duration.

While the radio range provides a road, it can be readily understood that it is necessary to provide some means of identifying the positions along the road. When the radio range was planned it was intended chiefly as an aid under conditions of low visability but not necessarily as a means for allowing flights to be made when low ceilings were present at the terminals, necessitating letting down through the overcast. No effort was made to provide adequate markers. A phenomenon associated with the long-wave radio range was present, which provided a means for identifying the location of the radio range. This was due to the coupling between the range antenna on the ground and the range receiving antenna on the airplane. When the airplane is directly over the transmitting antenna there is a momentary cessation of signals. The position of the airplane where these indications are received serves as a reference point which the pilot can use for calculating his further maneuvers. This indication has not been entirely satisfactory for several reasons. The momentary loss of signal caused by failure of the transmitter or receiver, or any associated equipment, serves to give the same "cone-of-silence" indication. Also, since the indication is a function of the antenna coupling, there are likely to be large variations in the exact location of the "cone."

A definite marker was established in 1938 by the installation of a new and independent facility. This new

(*Continued on page* 192)

FACSIMILE . . .

Facsimile, older than the electron tube, now becomes a practical means of rapid and inexpensive communication due to electronics. Ultimately facsimile machines in bus, railroad and plane terminals, office buildings, and drug stores, may replace the branch telegraph office

By J. H. HACKENBERG
Engineering Department
Western Union Telegraph Company

IT may seem paradoxical, but the art of facsimile telegraphy, which owes so much to electronics, was well developed years before the vacuum tube made its appearance. That is to say, the fundamental principles were well understood, a great number of scanning and reproducing methods had been developed, and systems of facsimile transmission were in actual operation. There were, however, two great stumbling blocks in the path of progress in the art which at that time prevented any widespread commercial use of facsimile telegraphy. These were the necessity for special preparation of the subject copy and the lack of suitable means of amplifying the signals so that they could be transmitted over appreciable distances. The photoelectric cell has since made it possible to scan satisfactorily almost any kind of subject copy without special preparation. The vacuum tube amplifier has made it possible to transmit these signals over great distances. Thus, electronics has made possible the commercial use of facsimile telegraphy which otherwise would still be the fascinating toy it was 50 years ago.

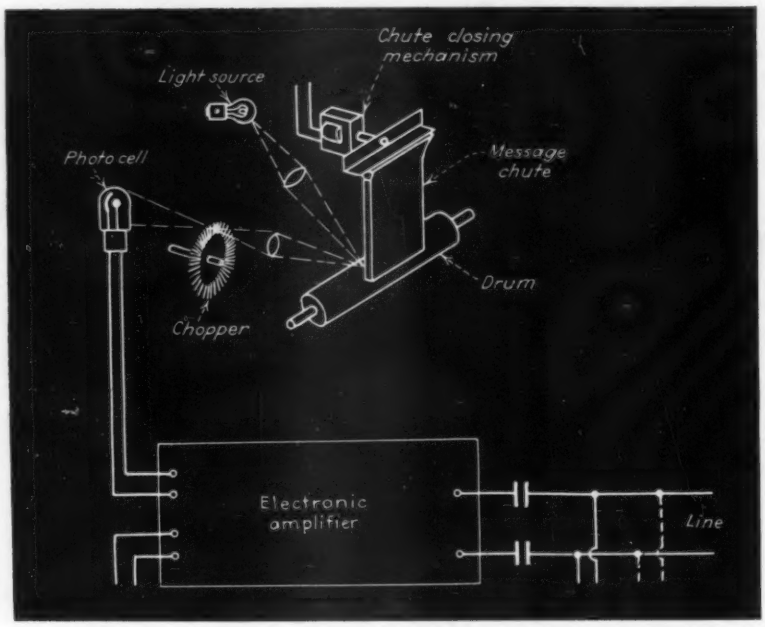
Even after the advent of the vacuum tube and the photoelectric cell, facsimile telegraphy was for some time more or less confined to one field, namely the transmission of photographs for news gathering agencies. This was dictated by the high cost of the photographic recording methods customarily employed and the individual attention required for each transmission. It was apparent that any extended use of facsimile telegraphy for the handling of telegrams would have to await the development of a simpler, cheaper and faster method of recording, as well as simplified and more nearly automatic transmitting and recording equipment.

Within the last ten years, great strides have been made towards the solution of both of these problems. The Western Union Telegraph Company has developed a record sheet known as Teledeltos which is fast, inexpensive and easy to use. It is dry, permanent and requires no processing of any kind before, during or after recording. It is light grey in color and recording appears black where a current (applied by means of a stylus riding on the surface) passes through the sheet. Either alternating or direct current may be used for recording, and individual pulses as short as 1/10,000 second duration are easily recorded. It has a fairly good half-tone characteristic, although the contrast is not as good as with photographic film due to the grey background. This paper is now being employed in all kinds of recording instruments where a simple, inexpensive record sheet is desired.

Western Union has developed for the use of its patrons a combination transmitter-recorder, the size of a teleprinter which requires no more than the wrapping of a blank around its drum and the throwing of a switch to send or receive a telegram. These machines are used to handle telegrams between a patron and the Telegraph Company's main office where the patrons' circuits terminate in an automatic concentrator at the main office. They may also be used between two patrons or between a patron's home office and his branch, etc.

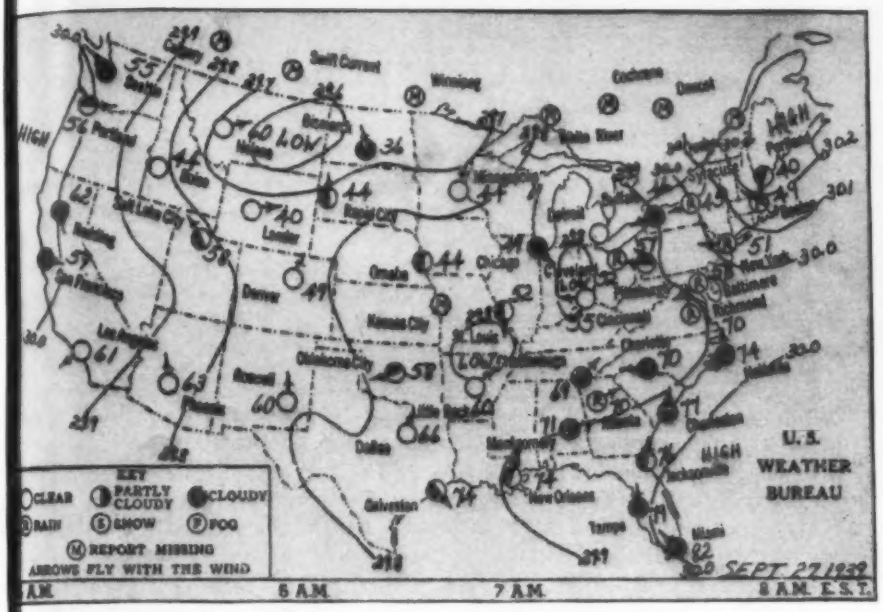
Transmitters and recorders are in

Automatic Transmitter

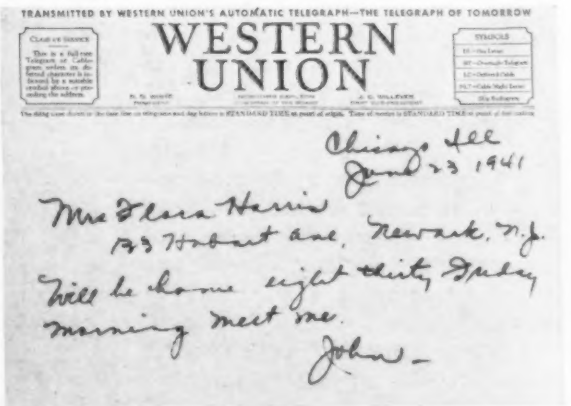


AUTOMATIC—How facsimile machine aids customer to get his telegram "in the works." He places his written message in a machine which wraps it around a cylinder, where it is scanned by a beam of light, a phototube transmitting to the central office the variations in light and dark of the original telegram

. . . OLD in Principle NEW in Practice



MAP—Application of facsimile to weather map transmission



FACSIMILE—Typical telegram in *exactly* the same form as it was written out in the telegraph branch office—not as a stunt or primarily to aid the customer, but as an actual aid to speedy pickup and transmission of message traffic

use on both trunk circuits and branch office circuits which employ a hopper of drums which feed in and out of the machines automatically as fast as the telegrams are scanned and recorded. The attendants at each end of the circuit simply keep the drums loaded with the messages to be transmitted and the recording blanks.

A Facsimile Machine Anybody Can Operate

A transmitter has been developed and has been in quantity use for some time which is as easy to operate as a mail box. The patron simply pushes a button and drops his telegram into a slot in the front of the machine. The telegram wraps itself around a drum, is scanned automatically and discharged into a receptacle in the bottom of the transmitter. Recorders have been in use for several years which employ a roll of Teledeltos, the recorded message being automatically cut from the roll and deposited into a receptacle. Another recorder has been developed which employs a roll of cut blanks which are automatically fed onto the recorder drum as needed, and stripped from it after recording and deposited into a receptacle in the front of the machine.

All of this automatic telegraph equipment employs Teledeltos as the recording medium. In some special cases other methods are employed as, for example, in the transmission of news pictures over submarine cable where, due to the high fidelity required, photographic recording is used. Another method, percussion recording, is employed where multiple copies are required. This is available on trunk circuits. Wax stencils or hectograph master carbons are produced from which multiple copies are made. This type of recording has been incorporated in a business machine produced by Western Union known as Multifax. This machine combines a facsimile transmitter and percussion-type recorder and produces wax stencils or hectograph master carbons of printed, typed, handwritten material, drawings, sketches, blueprints, etc.

A reproduction speed of approximately 14 sq. in. per minute is employed in most of the facsimile equipment although much higher speeds may be employed where circuit conditions permit. This is the equivalent of about 140 words per minute for single spaced typewritten subject copy, or 400 words per minute for newsprint. While the frequency band required (about 2500 cycles) makes facsimile transmission somewhat less economical of line than high-speed multiplex carrier telegraph systems, this factor is outweighed in most instances by the many advantages which facsimile possesses.

In order to secure the most efficient use of trunk circuits, facsimile is at present generally superimposed upon carrier telegraph sys-

(*Continued on page* 200)

SOUND . . . and Its Place in the Sun

The chief commercial market for amplification equipment today is in industrial plants and it is probable that this application will remain near the head of the list even after manufacture of equipment for entertainment, advertising and other peacetime uses is resumed

By F. D. WILSON
Operadio Manufacturing Company

THE ELECTRON TUBE can do more extraordinary things than any other device yet created by man. Its potentialities in the fields of industry, television, radio, medicine and many others are seemingly limitless. Billions of invisible electrons, racing through space inside vacuum tubes, are at the heart of one of industry's newest and most logical developments for speeding up production and human efficiency in both the war plant and the office—electronic intercommunication and paging systems.

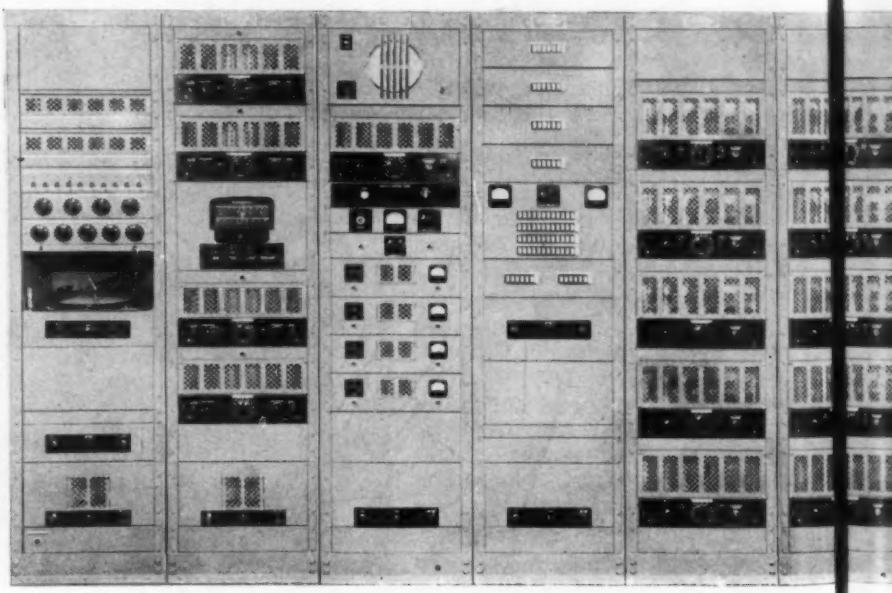
The "brain" of such a system is the amplifier rack and panel, where circuit priority is automatically determined and where the audio frequency impulse is received, filtered and clarified, increased in intensity and carried to any number of outlets—all in a split second. The "ear" of a paging system is the microphone —catching the slightest whisper and literally making it a command by passing it to the electronic "brain." The many "mouths" of a paging system consist of a large number and variety of loudspeakers and air-column horns, each engineered to its specific job and to its environment factors such as the noise in the area to be covered, acoustical factors, and specific functions required of the system. Loudspeakers may be mounted in the open or behind grilles . . . on ceiling, pillar, or wall . . . inside, or outside exposed to the weather.

Modern Industrial Installation

In a vast aircraft engine plant designed for Wright Aeronautical Corporation, such a sound system conserves executive time, builds worker morale, speeds production of vital equipment for the men on the fighting front. This modern installation is used to broadcast voice, music, time signals and other information all over the enormous plant at any hour of the day or night.

Two separate equipment groups are used. The main system handles: (1) Fire signals, (2) Time signals, (3) Plant police calls, (4) Switchboard paging, (5) Maintenance calls, and (6) Local operation. Precedence is established in that order. For example, if the fire signal is sounded it automatically locks out any other service that is using the system. A smaller, supplementary system, is used to bring radio or phonograph music to five cafeterias.

The fire signal is a tone produced by electronic oscillation. From any fire box in the plant a signal can be sent over the entire system, cutting out any other service in use at the time. The signal is coded to indicate the location of the box originating the alarm. The time signal is used for stopping and starting work on each shift. The tone is different from



BIG JOB—This installation, in a Wright Aeronautical plant, performs many functions. It furnishes entertainment, permits paging from a central switchboard, may be used for intercommunication between specific points, transmits time signals, handles maintenance, fire and private police calls

MORALE—Sound got its initial toehold in industrial plants when early installations proved that "music while you work" increases production. Two Westinghouse factory employees here are selecting records for the day

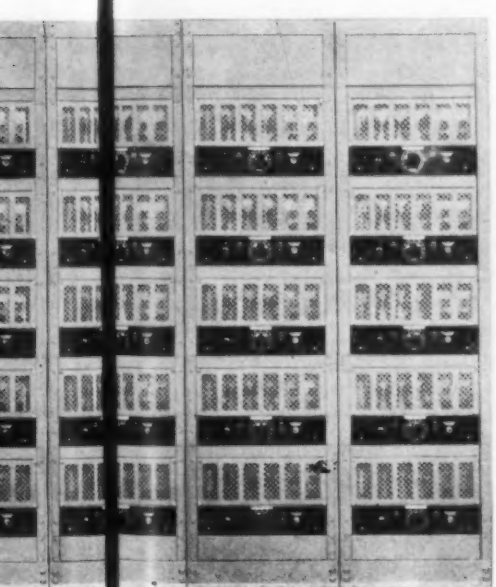
the fire signal. When machines are in operation an automatic control doubles the volume of the signal to carry above the noise. Police service is maintained by the use of coded voice signals to the guards throughout the plant.

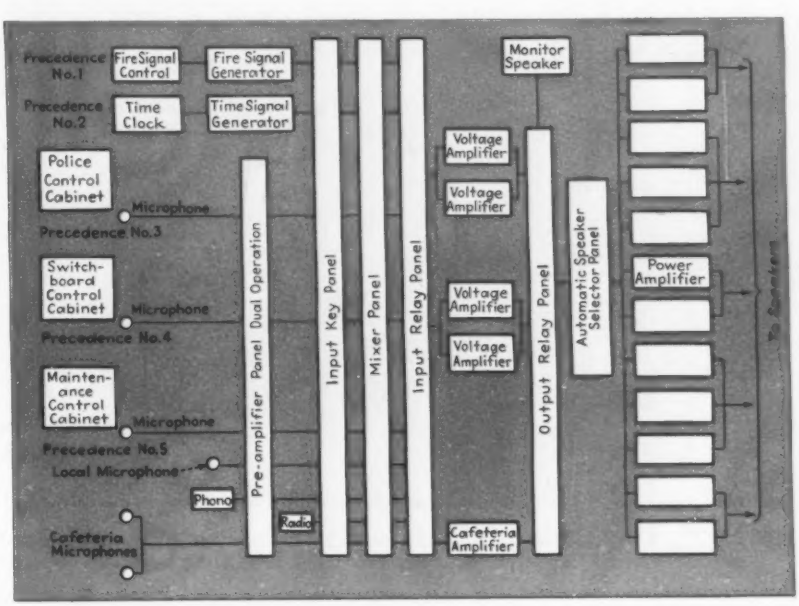
One microphone is in constant use for switchboard paging. There is such a large volume of calls to the plant that one girl is employed full time to handle telephone requests for paging. The plant telephone system has a dial number for paging service and when this number is dialed the girl answering fills out a "Paging Requisition." She passes this form to another girl, who selects the proper key for paging the area to be covered. Paging is done over five different circuits. Five different areas can be paged separately or in various combinations. A master key cuts in all five circuits at once.

The plant's Chief of Maintenance is provided with a panel similar to that in the office of the Chief of Plant Police. If a machine should break down, or other trouble develop, the maintenance crew can be summoned and instructions instantly given over the voice paging system.

For local operation, announcements can be made direct from the amplifier panel and rack in the control room. Executives may issue instructions or make addresses to the entire factory personnel by plugging in the microphone at the control panel. Radio programs, or phonograph music, can be sent into the entire plant, or to any part of it.

Dual equipment is installed and so wired that the failure of any vital part of the sound system automatically switches a reserve unit into the circuit.





The use of sound amplification equipment for advertising purposes came into prominence during the 1930's and it was considered almost an advertising necessity by many large companies. One such concern, Servel, had 150 tow cars and trailers, all equipped with sound. Salesmen driving the cars used microphones to publicize refrigerators and other home appliances, made mass demonstrations at fairs. Another company hired the Goodyear Airship "Puritan", which hovered at 1200 ft. over a Miami theatre during the showing of "Lost Horizon," while horns sold the story being shown, from the air.

Conventional Outdoor Uses

Many people have seen and heard police "safety cars," but few realize their full worth. The Niagara Falls police department, for instance, has two such cars, each with a large all-weather horn mounted on the top. The cars are used to educate not only residents of the city but also the thousands of tourists who visit it regarding traffic regulations. The cars have also proven indispensable in emergencies such as large fires and other unusual events where crowd control is necessary.

It would be almost impossible to hold many large affairs drawing tremendous crowds of people without the use of sound systems. Football crowds are kept advised of scores, plays, yardage, players' names and substitutions. In such famous football bowls as Northwestern University's Dyche Stadium and Rockne Stadium at Notre Dame, sound systems carry the spoken word to thousands of "fans."

The famous Easter Sunrise Service at Miami Beach, held on the water front, has attracted crowds estimated at 35,000. Such a gathering covers a considerable acreage and twelve large, well-placed speakers make the entire ceremony audible to everyone.

Amusement parks too, have found outdoor types of sound installations very useful. On many large public projects, such as Boulder Dam and the San Francisco-Oakland Toll Bridge Plaza, operations are controlled from a central position. The National Air Races in 1930 were held at Glenview Airport in Illinois and even at that early date throngs spread over a vast area were advised of events and winners by means of sound. An installation at Bendix Field in Indiana is used for both paging and intercommunication. From the microphone in the control tower messages can be switched to any remote connection.

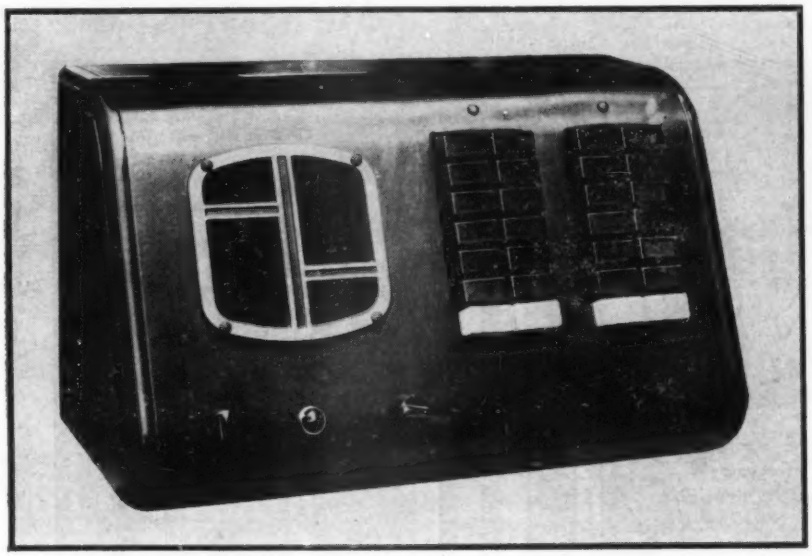
Other Typical Uses

For direct personal communication between executives, department heads, and secretarial assistants, more or less "packaged" intercommunication systems are offered to modern business. Relatively simple installations involving compact units provide instant contact between the key personnel of any organization. Information is obtained from any department while holding the long distance telephone, relieving telephone blockade. A conference can be held with several members of the organization, each with their data in front of them, at their own desk. A secretary or subordinate may be called, and may answer from any point in the room, without interrupting his work.

School intercommunication systems attained great popularity before the war changed many things. In a typical installation a small remote control unit is placed on or near the superintendent's desk and the superintendent uses it to reach every room singly, or the school in its entirety. He can send radio rebroadcasts wherever he wants them in the school, can listen in on school activities, receive reports from the teachers, and can in some instances be called by the individual class rooms. The amplifier itself is installed in a closet or, possibly, down in the basement.

A most unusual intercommunication system was installed a few years ago by a newspaper. In the office of the Minneapolis Star, a microphone, pre-amplifier and a phonograph turntable were connected through a master central unit. Telephone wires throughout the city connected with 45 outlying "carrier" depots. These depots, small metal houses where the distributors get their papers, have speaker units installed in each of them. When the kids go for their papers in mid-afternoon, data is received at their depots over the system on new "deals" for obtaining subscribers. They hear pep-talks, information on new subscription contests, the latest news. Depot station circulation managers are able to report back to headquarters promptly and reporters have often sent news in much quicker than by ordinary telephone.

As to the future, the development and use of unusual electronic equipment for military purposes in war will certainly bring new advances in peace. The sound equipment business will undoubtedly benefit to a considerable extent from certain phases of current design work, particularly with respect to ruggedness of equipment.



PACKAGE JOB—Intercommunicator units of this general type, used in groups, find many applications in the field of business

HEARING AIDS...
Boon to Mankind

By F. W. KRANZ
Vice-President, Sonotone Corporation

INCONSPICUOUS—Conversion of sound waves into electrical impulses facilities amplification. It also permits intelligence to be transmitted over tiny, flexible wires from a microphone unit concealed about the person to headphones such as these, placed within or behind the ear

COMPACT—Miniature microphones, vacuum tubes and other component parts developed specifically for use in hearing aids nest together inside streamlined plastic cases. Connected to the transmission cable of the two-tube device pictured here is a bone-conduction receiver, with an optional air-conduction receiver just above it

A HEARING AID is a device which augments the amount of sound energy reaching the ear of the user. This augmentation may be accomplished in a number of different ways:

(1) The device may merely collect more sound energy than the ear by virtue of having a larger area. A hearing trumpet is a good example.

(2) The device may simply prevent sound from being dissipated during transmission. A speaking tube falls in this category.

(3) The device may actually amplify or increase the amount of sound energy initially available. Modern hearing aids are in this class.

In a modern hearing aid sound energy is converted into electrical energy. This electrical energy is transmitted along wires and finally converted back into sound energy.

Mechanical vs. Electrical

There are two advantages. One advantage is that electrical energy can be transmitted to any desired point within a reasonable distance without appreciable loss. The other advantage is that it is possible to utilize the electrical energy of a battery in such a way that more sound may actually be received from a communication system than is put into it.

The essential elements of such a system are:

The Transmitter, which converts sound energy into electrical energy.

The Receiver, which converts electrical energy back into sound energy.

The Line, which connects the transmitter to the receiver.

The Batteries, which energize the entire system, providing an auxiliary source of power.

The Amplifier, which increases the amount of available power by "triggering" off auxiliary energy stored up within the battery.

(Continued on page 204)

BIG BUSINESS

$10,000,000 is the estimated 1942 sales total for the hearing-aid field, this figure including complete instruments, replacement batteries and tubes

PICTURES by

First cousin to facsimile and second cousin to television, transmission of illustrations along with a story fills an obvious need in the newspaper business. Future expansion of the service depends upon the speed with which additional portable units can be placed in use

EXAMPLES—These two illustrations were sent over a relatively low power radio transmitter in China to the *New York Times*. They are shown exactly as they were received, without re-touching

From the Technical Viewpoint

By AUSTIN G. COOLEY
Times Telephoto Equipment, Inc.

FACSIMILE telegraphy, the art of transmitting pictorial and other graphic subject matter, is nearly as old as code telegraphy. Early difficulties in the way of securing satisfactory recording of facsimile copies retarded commercial adoption whereas code transmission faced no such problem.

Past, Present, Future

In 1912, Prof. Arthur Korn, had a photo transmission network operating on a commercial basis between London, Paris, Berlin, Manchester, Copenhagen and Munich. Little was done in the United States, however, until shortly after 1920, when the science of electronics was applied to the basic system as developed by Korn. Ever since the 1924 Republican Convention in Cleveland, leading American newspapers have been able to give us up-to-the-minute news pictures on all the more important stories.

The Associated Press opened up an elaborate picture transmission network between fixed stations in January, 1935. In February of that year the *New York Times* published news pictures from San Francisco, transmitted by portable equipment developed in its own laboratories. Shortly afterward, International News Photos made tests with portable equipment. Associated Press similarly developed a portable system and competition for technical superiority was further enlivened by the entry of Acme News Photos into the field.

As war clouds appeared on the horizon in Europe, portable newspaper facsimile equipment presented the reading public with a preview of Army maneuvers and proved that

ES by Wire and Radio

EQUIPMENT—Pictures are transmitted or received over telephone lines by this typical portable machine by removing the receiver from the hook and placing it on a pickup unit

equipment was no laboratory toy but could rough it in the field and deliver the goods. Certain features were eventually added in accordance with Signal Corps requests. We cannot describe the resulting designs now. We can only say that facsimile is transmitting important weather maps and has carried hand-written notes between our President and the Generalissimo in Chungking.

Brooks Atkinson of the *New York Times* reports from Chungking that facsimile equipment will be placed throughout China with the result that, after the war, facsimile may replace all Chinese telegraph systems. The reason is obvious. In transmitting copy for one edition of a newspaper in China, ten Chinese are required at the transmitting end to convert the characters into a cipher code which can be transmitted by Morse or printing telegraph. Ten more are required at the receiving end to convert the copy back into Chinese characters.

Typical Transmitters and Receivers

Most transmitters carry subject matter on a rotating drum driven by a synchronous motor whose speed is accurately controlled by a tuning fork. Either the optical system moves on a carriage along the length of the drum or the drum travels along its axis in front of the optical scanning system. Signals developed in a phototube, included in the optical system, are amplified by other tubes sufficiently for transmission over a communication channel.

For direct telephone line or radio connections an output signal having a level of zero db is generally sufficient. For newspaper work, some systems have been providing an output signal level of plus 25 db so that equipment may be inductively coupled to telephone receivers. Inductive coupling arrangements permit photographers to set up portable phototransmission equipment at any telephone substation without installation delays which would be involved if direct line connections had to be made.

For high quality photographic work recorders are mostly of the drum type, having a crater-lamp or light-valve in the optical system. Crater-lamps are usually of the gas-discharge type, similar to those used in the early days of sound movies. Light valves used include an incandescent lamp and a magnetically controlled mirror or shutter, similar to those used in most present-day sound movie recording equipment.

Receivers intended only for black and white copy are sometimes built for direct recording on a continuous strip of paper fed from a roll about eight inches wide. Recording is accomplished by a magnetically controlled stylus in some systems. Others make use of color changes produced by the passage of current through a paper dampened with a chemical. A relatively recent continuous strip method makes use of a direct recording paper such as the Western Union "Teledeltos" type. In this case marks are made by the electrical burning off of a white surface coating over a black paper backing.

From the Press Viewpoint

By LEON DECKER

Press Association, Inc.

ONE OF THE MOST revolutionary advancements in news gathering—the transmission of pictures by wire—owes its development largely to the magic of electronics.

Readers of today's newspapers scan the headlines for the day's big news, then capture with their eye all the drama and impact of the news. This is possible through pictures which are flashed to all corners of the land with the speed of light. Readers give little thought to the innovation that enables them to enjoy this second dimension of news. But the development of what may truly be called "the miracle of modern news gathering" is an exciting story.

Dramatic Commercial Debut

The beginning of this new era in American journalism came with the start of the new year on January 1, 1935. A big airliner had crashed deep in the Adirondack Mountains in New York. Searching planes had found the wreckage and an aerial picture had been made. It was "page one" picture news everywhere.

Technicians put the picture on the

(*Continued on page* 208)

SOUND RECORDING Depends Upon Electronics

Sound-on-film for motion pictures; sound-on-disc for broadcasting, for the home and for industry rely upon electron tubes for recording and play-back and for control of quality

MANY of us think of sound recording as a comparatively recent development, particularly in the case of talking pictures which came into commercial use about 1926. However, the basic principles of recording sound on films were suggested over sixty years ago. Various improvements were made during the following forty years but no practical application was found until the early 1920's. An important reason why this development did not take commercial shape for such a long time is that the principles involved were impractical until the development of the electronic art reached the stage where amplifiers and phototubes could be produced commercially.

The introduction of amplifiers permitted the use of less efficient sound pickup and engraving methods, but the lower efficiency was more than compensated by the wider range of frequencies recorded and by lower distortion.

Amplifiers Have Many Advantages

Amplifiers also make it possible to "monitor" and to play back a record as soon as it is made so that any defect in the recording may be detected and a new recording made, if necessary, while the musicians are still assembled. Amplifiers also make it possible to engrave several records simultaneously from the same source, and to re-record from one record to another in order to add other sounds or to alter the relative intensity of various bands of frequencies. Examples of "equalization" used in disc recording are (a) reduction of amplitude at low frequencies to avoid overcutting, (b) pre-emphasis or accentuation of high frequencies to reduce the relative amount of noise reproduced from the record, and (c) equalization to compensate for non-uniform response of any of the elements of the recording system.

Similar improvements have also been introduced in the reproduction of disc records. Electrical pickups are much more uniform in their response than the best mechanically operated types. Another advantage of the electrical system is that the frequency response can be readily adjusted to accurately match the recording characteristics. It is also very easy to adjust the level of the sound reproduced from the record and to a certain extent the scratching noise may be reduced by electrical filters.

Sound-on-film Depends Upon Electronics

Sound-on-film recording is virtually impossible without electronic devices. Aside from the ever-present amplifier, electron tubes are used for such widely different purposes as changing light fluctuations into electric currents, as in the phototube, and regulating motor speed, especially on d-c circuits.

One recent contribution of considerable importance is the volume limiting amplifier. This permits recording sound at a comparatively high level on the film (giving proportionately less noise when reproduced) without the danger of overmodulating, and also protects the recording element from excessive currents. Another device is a noise reduction unit which, in addition to the usual amplifier and rectifier tubes, may utilize a carrier frequency oscillator, modulator, and a copper-oxide rectifier as a d-c amplifier.

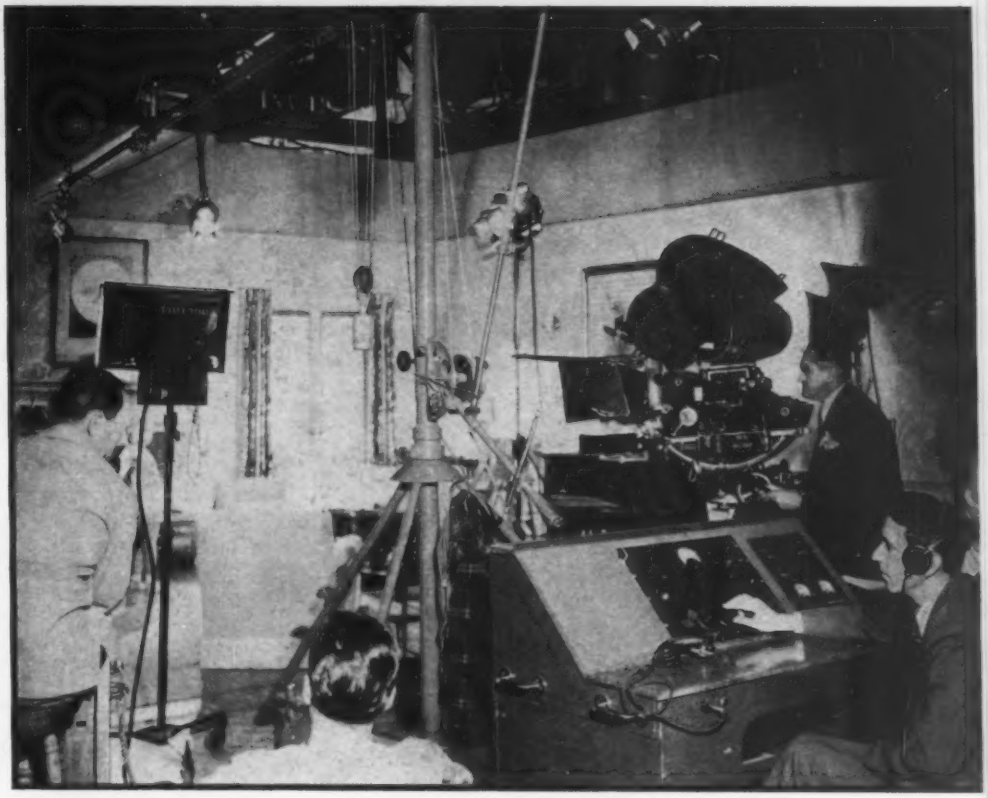
A phototube monitoring unit is often provided to check the operation of the recording equipment right up to the film. This is done by diverting a portion of the modulated light beam into a phototube, amplifying the phototube current and converting these currents into sound by either headphones or a loudspeaker. The sound so reproduced is practically indistinguishable from sound derived from electric currents which have not been transformed into modulated light and back to electric currents again. Any overloading or other source of distortion may be detected by comparing the sound from the direct and the phototube monitoring circuits.

In the early days of sound-on-film recording an electronic device in the form of a gas discharge tube was used extensively as a light modulator. These tubes have now been largely displaced in favor of mechanical modulators such as light valves and mirror galvanometers, due to a large extent to the difficulty in producing tubes giving out enough light to suitably expose sound-recording film. However, this type of modulator has a number of inherent advantages, such as simplicity and absence of resonance, which are not possessed by other modulators. Perhaps future developments in gaseous or electron discharge tubes will make it possible to once more enjoy these advantages together with an adequate light output.

Another interesting application of electronics to sound-on-film recording is the "negative playback ampli-

By C. R. KEITH

Electrical Research Products Division, Western Electric Company, Inc.



STUDIO—The "mixer man" at lower right is adjusting the output of the microphone to a value proper for operating recorders in this typical studio shot. The recorders are in air-conditioned rooms in another part of the building, the sound-carrying electrical currents being sent there by wires. The mike hangs on a boom supported by the mast

fier." It is easy to show that a negative variable density sound track contains certain distortions which are automatically compensated by the photographic process of printing and developing the positive print. In the usual studio procedure the negative is not used for reproducing sound but only for making prints from which the sound is reproduced. However, there are some circumstances, particularly in newsreel work, when it is desirable to reproduce sound directly from the negative. To make this possible with a minimum of distortion, an electronic circuit has been devised which produces the same kind of compensating distortion as is produced by the positive photographic process. A combination of feedback, non-linear vacuum tube characteristics, and d-c amplification is utilized in a very ingenious manner.

Motor Control by Electronics

Electronic circuits are also used for maintaining accurate speed control for motors driving either sound recording or reproducing equipment. This type of control is particularly applicable in areas having only d-c power, or where the a-c supply is not sufficiently well regulated to permit the use of synchronous motors.

Another electron tube application is the phototube densitometer. This instrument is used to measure the characteristics of films used for sound and picture recording, and is a most useful device to control picture quality. The densitometer is coming into use outside the motion picture industry.

One recent development is the "sprocket hole control track" which is used for automatically varying the gain of the reproducing system amplifier and also for connecting additional loudspeakers. As its name implies, a variable-width track is printed in the spaces between successive sprocket holes. A simple illuminating and scanning system is provided in the sound reproducer, including a phototube for producing corresponding electric currents which are used to control a variable-gain amplifier with the special characteristic that the change of gain is dependent only on the width of the track, and not on the intensity of the exciting lamp.

Another form of control track recording makes use of a very narrow track (5 mils wide) located in the black margin between the standard sound track and the picture. Frequency modulation is employed to increase the volume in the theater, reduce the noise for low sound levels, or for both purposes.

Three-dimensional Sound

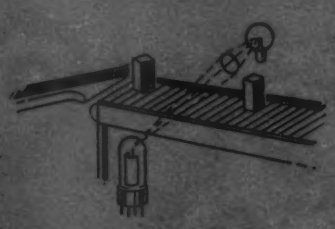
Extensive use of electronic devices is found in recent equipment developed for stereophonic sound reproduction. An important feature of one such system is the very high signal-to-noise ratio, which is obtained to a large extent by means of automatic compression and expansion. This compression-expansion system may be used to increase the volume range, to reduce noise, or for both purposes.

Further Simplification

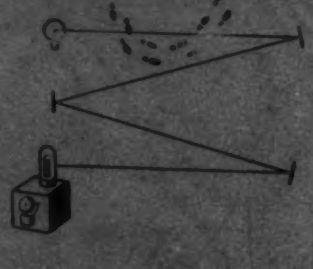
Although great strides have been made in improving sound recording and reproduction in the last twenty years, still further improvements will undoubtedly be made as a result of electronic and other technological advances. One line of improvement may well be further simplification and reduction of cost of both recording and reproducing equipment. Stereophonic sound presents an alluring prospect, but there still remains further development in order to make the system suitable for use throughout the industry. Altogether there are still plenty of problems to the solution of which the electronics engineer will undoubtedly contribute in a large measure.

In industry, the electron tube is playing an increasingly important role in process control, safety of plant and personnel, and increasing production.

TRAFFIC



PRODUCTION



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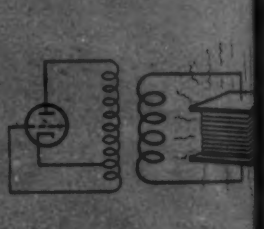
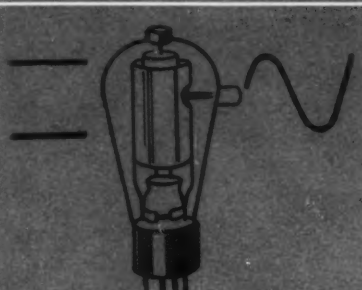


PROCESSING



POWER-CONVERSION

CONTROL

MAINTENANCE

COUNTING

New Force in INDUSTRY

RESISTANCE WELDING
speeded, improved by tube control

By G. W. GARMAN
Electronics Section, Industrial Dept.
General Electric Company

THE DEVELOPMENT of controls for resistance welding machines was one of the earliest achievements of electronic engineers in the industrial field. Present day interest in, and adoption of, electronics generally as a practical tool can be traced to a very large degree to the success of this application.

Resistance welding is one of a number of methods of fusing metals together. Others are brazing and soldering, arc welding, torch welding and the blacksmith's hot forging. Resistance welding consists of applying pressure by means of copper alloy electrodes to two or more pieces of metal and then heating the adjoining surfaces of the work to the fusion or melting temperature by allowing electric current of a definite magnitude to pass through the pieces for a definite length of time. When the current flow is stopped, with pressure still maintained, the melted metal "freezes," binding the pieces together as a single unit.

Although there are many forms of resistance welding, such as spot welding, projection welding, pulsation welding and seam welding, the basic method in all cases is the same. The nature of the weld depends upon such factors as electrode pressure, size and shape; type, thickness, and surface condition of metal to be welded; time of current flow, and, of utmost importance, the magnitude of this current. The last two factors can be controlled electronically, while the others are subject to mechanical control.

There are at the present time two basic methods of obtaining the necessary welding current. These are the a-c and the stored-energy methods.

A-C Resistance Welding

The actual welding current required to melt or fuse two pieces together depends upon the type of metal being welded and its thickness. When welding high-resistance metals such as stainless steel of thin gauge, only a few thousand amperes are required. When low-resistance materials such as aluminum alloys are welded, 20,000 to 60,000 amperes are required.

The simplest and oldest method of obtaining this current is by means of a step-down transformer (welding transformer), the primary of which is connected through an interrupting device to the plant electric power distribution system operating at 220, 440 or 550 volts. Even though a step-down transformer is used, the primary current may still be several thousand amperes. Prior to the introduction of electronic control, mechanical devices—such as magnetic, air-operated or synchronously driven motor-operated contactors and "pass-through" switches—were used to make and break this current.

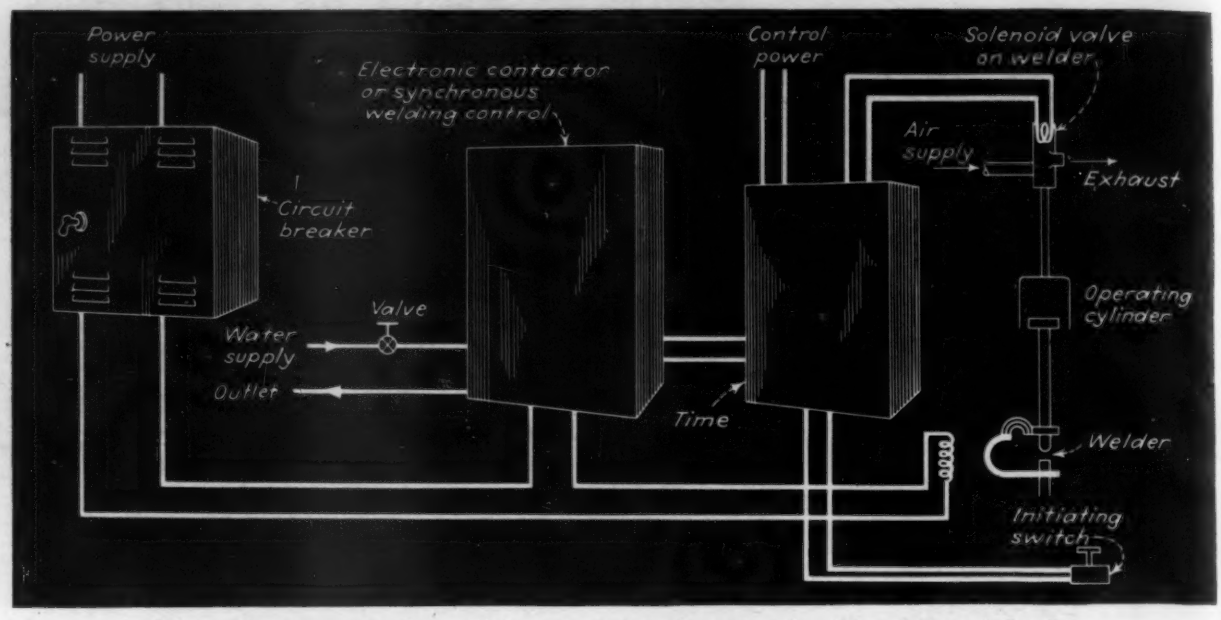
The problem of mechanically making and breaking such a current from 50 to 1200 times per minute without excessive maintenance is a real task. For uniform results, the welding circuit must be closed consistently not only for a definite length of time but also, to obtain consistent

BELLWETHER APPLICATION

One of the earliest large-scale uses of tubes in industry, resistance welding controls proved under actual field conditions that electronic equipment of proper design can "take it."

Even today, with electronic devices going into plants for many purposes, resistance welding controls account for a respectable percentage of all the tubes reaching industry.

Typical Welding Control Setup



Tubes perform many functions. Their work starts in the unit at the right, which controls other tubes in the contactor and power supply units. Operation may be fully automatic, permitting the welder to devote full time to insertion and removal of work

values of welding current, at a definite point on the a-c voltage wave. Electronic control assists materially in obtaining consistent results because it is without inertia and friction and can control precisely the start and finish of welding current. In addition, since electronic control has no moving parts or arcing contacts, maintenance time and expense are much less.

Engineers who have studied oscillograms of welding current when a standard magnetic welding contactor is used and when electronic control is used have noted that the primary current is several times normal when the magnetic contactor is used, thereby causing excessive voltage drop and additional heating in the distribution supply. This condition increases the probability of light flicker and interference with other equipment connected to the distribution system. Also, since the heat generated in the weld depends upon the square of the welding current, even a small variation in its value can cause an appreciable change in the heat generated, which, in turn, causes a variation in weld quality.

The importance of precise control in seam welding is great, as the bad effect of erratic closing of the welding circuit can, under certain conditions, become cumulative, thereby causing a still greater variation in line current, as well as weld quality. Welding current for a seam welding application can be controlled electronically with a high degree of precision.

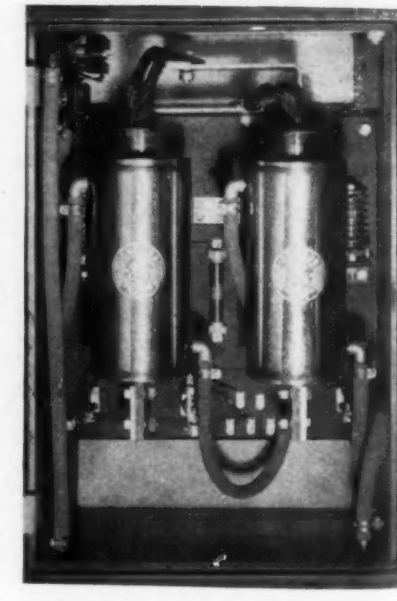
Many Industrial Advantages

To illustrate the advantages of precise electronic control in one typical plant; 21,000 refrigerator evaporators, containing 1,250,000 spot welds, more than 1,400,000 inches (22 miles) of gas-tight seam welding and 6,000,000 inches (94 miles) of intermittent seam welding, were welded without a single unit being rejected because of faulty welding.

The story of a-c electronic control could be ended at this point by merely stating that through its use production has been increased greatly and millions of dollars have been saved, but, like most developments, the story is never completed. For with each sucessful application of resistance welding new control problems arise.

To understand fully the contribution of electronic control to the metal fabricating industry, a brief sketch of the development of a-c electronic control may be of value.

With the general adoption of electronic control some 12 years ago, the only tubes available which were economically justified were the hot-cathode thyratrons. These had limited ratings up to 12½ amperes but could be operated as high as 6600 volts. With many applications re-



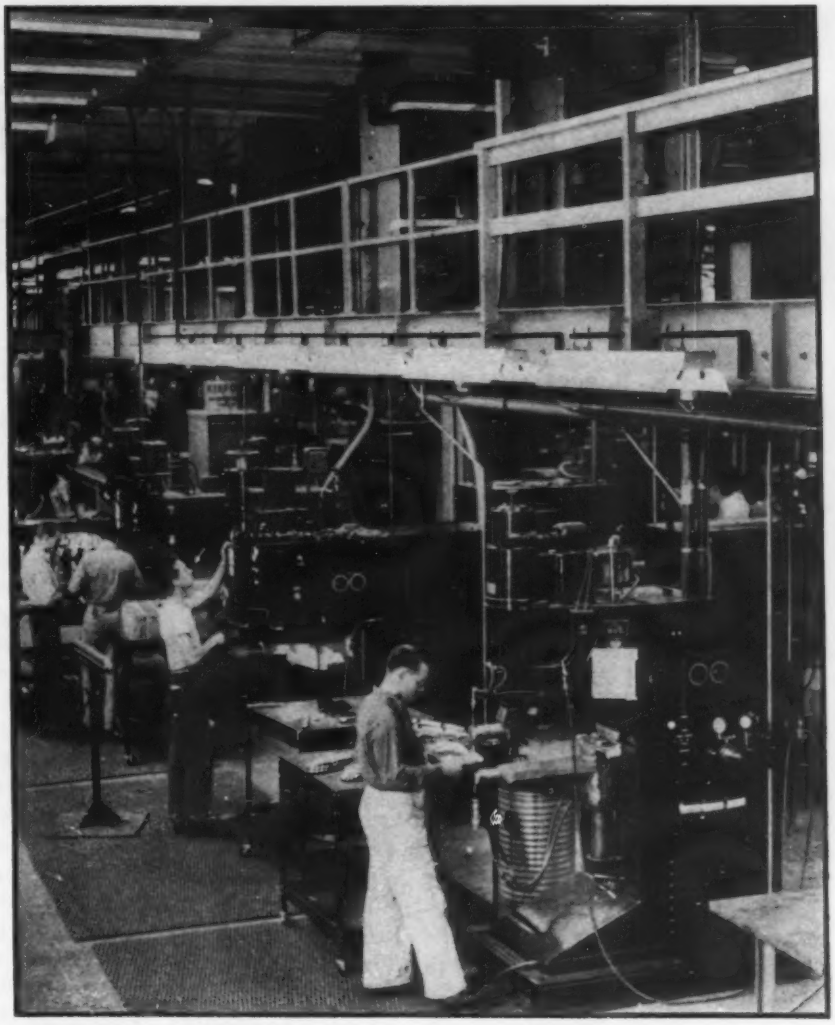
CONTACTOR—Two ignitron tubes take the place of bulky and complicated mechanical switches, opening a 9500 ampere, 230 volt circuit from 50 to 1200 times a minute without arcing

quiring control of several hundred amperes, the logical procedure was to use a so-called "series transformer." The primary, or low-voltage winding of this transformer was connected in series with the primary of the welding transformer. When the thyratrons connected across the high-voltage winding were allowed to pass current, the transformer was effectively short circuited, allowing substantially full voltage to be impressed on the primary of the welding transformer. With the thyratrons shut off or prevented from passing current, the impedance of the primary winding was sufficient to allow only a small voltage to be impressed on the welding transformer. Even though this equipment was relatively expensive and bulky, and was limited to the control of a welding load of about 350 kva maximum with a single pair of tubes, or 700 kva with two pairs of tubes, it was used extensively, particularly for seam welding of gasoline tanks, refrigerators, and similar products.

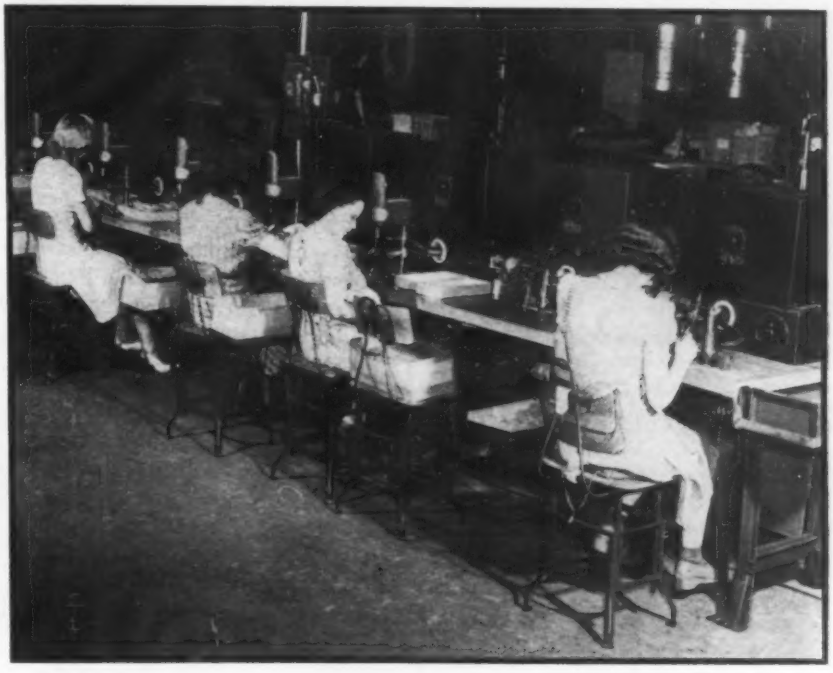
It was, however, this type of control combined with an electronic timing circuit that demonstrated the full advantages of controlling welding current precisely and proved that a resistance welding machine with the proper type of control was a precision machine tool. Without electronic control the resistance welding machine manufacturers were handicapped. For, no matter how well they designed their machines, both the quality of the weld and the field of application were limited.

With the development of the sealed-off water-cooled ignitron tube, the limitation of price and size of electronic control was removed. In addition, while the previous control using a single pair of tubes was limited to 350 kva, the water-cooled tubes could control for short periods of time approximately 2,000 kva. Furthermore, even without the precise timing and control feature, two of these tubes could be connected as a single-pole electronic switch or contactor. Such a contactor had the advantages of long life, low maintenance and silent operation. Prior to the war, hundreds of these contactors were installed in the automobile industry. A survey indicated

(*Continued on page* 210)



INDUSTRIAL INSTALLATION—A-c resistance welding equipment, complete with modern electronic controls, in use in a large plant



TUBE PLANT—Resistance welding controls are widely used by the electronic industry itself, as well as by other industries for which it builds such controls. Here thyratron tube control panels facilitate welding of radio tube structures

PROTECTION by Electronic

Important in peacetime, the safeguarding of commercial premises and industrial plants against burglary, vandalism, fire, smoke and water damage is even more so during war, when acts of sabotage may be as destructive as loss on the actual fighting fronts

IN the field of protection, electronics is assuming an important role in guarding industrial plants and other properties against intrusion, burglary and various acts that might lead to sabotage. The systems used for this purpose are of two types: photoelectric, in which the detecting medium is a beam of invisible light; and body capacity, which depends upon the change produced when a person or other object enters an electric field.*

Much of the pioneering in these types of sytems has been done by the so called "central station" protective companies, firms which, during the past ten years, have installed and operated in connection with their central station protection services thousands of photoelectric alarm systems for both indoor and outdoor protection. Up to the beginning of the war such companies installed body capacity alarms chiefly for the protection of safes and metal cabinets, but with the demand for increased protection for war plants these systems also have been developed for the protection of open areas, both indoors and out.

The photoelectric system, usually called the "invisible ray" alarm, was originally employed as an indoor burglary trap, an alarm being caused when an intruder intercepted the invisible beam of light. This system supplemented conventional protection of screens, foils and contacts. The demand quickly arose, however, for its use outdoors over comparatively long distances, and systems soon were developed to meet these requirements. One of the earliest outdoor installations was for the protection of a waterfront stretch of nearly 3000 feet over the water to guard against instrusion from the sea. This required mounting the projecting and receiving devices on tidal floats and the use of specially designed equipment throughout. The long-distance systems developed later were a modification of this system.

The development of photoelectric protection systems naturally began with attempts to adapt standard electric eye devices ordinarily used for opening doors, counting persons and objects, etc., but these did not prove satisfactory to meet the exacting requirements involved. Consequently, it was necessary to develop special equipment capable of long range operation and involving features designed to insure reliable operation with infrared light and under varying conditions. These systems now have a high degree of sensitivity, are thoroughly stable, will operate on reduced voltage, and the devices are constructed so that they can be easily mounted and adjusted in any location.

CENTRAL STATION—Men in background watch "drops" remotely operated when trouble occurs on distant protected prem-

Several photoelectric systems have been approved by Underwriters'

BIG BUSINESS

It is estimated that there are at least 30,000 so-called "central station" installations in the United States, maintained and policed by organizations specializing in such service.

In addition, an untold number of protective installations have been made by individual business firms purchasing equipment outright and doing their own policing.

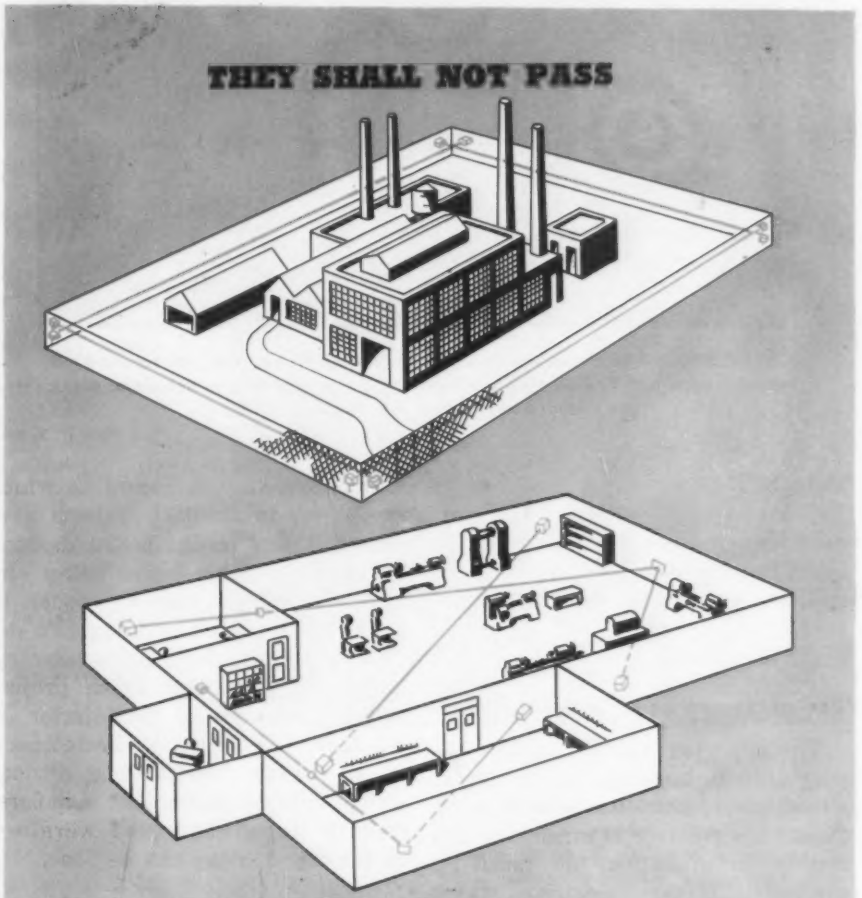
* Editor's Note. Recently a third method has been announced. This utilizes a Rochelle-salt type of vibration detection unit affixed to the fence surrounding a plant. Vibrations of the wire generate a voltage which is utilized to sound an alarm. No details of this method are available as yet.

OF PROPERTY

Methods

By **PAUL M. FARMER,**
Chief Engineer
American District Telegraph Co.

ises, pass data to dispatchers in foreground. Special police speed to the scene and local police or firemen are called



OUTDOORS—Invisible light-beam and phototube devices, capacity alarms utilizing radio waves and sensitive controls which transmit a warning signal when disturbed by vibration constitute barriers that are hard to defeat

INDOORS—Criss-crossed patterns of light catch intruders who may succeed in evading electrical devices guarding doors, windows and even walls and ceilings. Safes and vaults may be further protected by supplemental body-capacity and sound operated alarms

Laboratories for protection of inaccessible openings, ceilings, floors and party walls, eliminating the need for other types of protection usually difficult or expensive to install. To obtain certification of the alarm system for reduced insurance rates the Underwriters require that a network of invisible rays be reflected back and forth inside the premises so as to subdivide floor space into at least five approximately equal areas.

The maximum length of beams for indoor systems is about 150 feet in a straight line from light source to receiver. When mirrors are used to reflect the beam back and forth across a room the beam length is reduced by approximately 50 percent for each mirror used. This is a practical rather than a theoretical limitation, based upon considerable operating experience. The indoor system may be used also for short distances out-of-doors, in which case the light source and receiving units are equipped with protective hoods to shield the lenses from the weather and to reduce extraneous light.

The protection of outdoor areas ordinarily requires a photoelectric system capable of projecting a much longer beam than indoor systems. Such systems usually are installed for boundary protection, particularly as a secondary line of defense inside of wire fences or other types of physical barriers, to detect and report the presence of intruders. The equipment for such systems is necessarily of a different character than that used indoors. The light source and receiving units are completely weatherproof and ruggedly constructed to withstand outdoor conditions. The beam, which generally has more power than the indoor system, in conjunction with its receiving device, is effective over distances up to 500 feet even under adverse conditions such as rain, snow, sleet and fog. Two

HOT CORNER—Saboteurs successfully scaling the fence in the background still have to face invisible light beams emanating from the two photoelectric alarm devices criss-crossing the premises inside

light bulbs, each capable of operating the system independently, are sometimes provided for safety. The beam is large enough to avoid interruptions by small birds and animals, bits of flying paper and leaves, or other small objects.

Use of Photoelectric Systems Outdors

The important feature of this outdoor system, however, is the use of a modulated light beam to whose frequency the receiver is tuned. By this method of operation the receiving equipment is very sensitive, which makes it possible to operate over long distances. Furthermore, the receiving unit will respond only to the light projected from the light source, and no other light that might be applied accidentally or maliciously will prevent the system from operating. The system is also designed so that momentary power failures will not cause alarms.

Photoelectric systems also can be used for fire detection, but such systems have not been developed extensively because of relative equipment costs and the wide use of exceptionally effective automatic fire detecting systems of other types, particularly those operating on the rate-of-temperature-rise principle. Photoelectric devices, however, are used extensively for fire and smoke detection in air duct systems, particularly large air conditioning installations, where fires are likely to start in filters or in combustible material drawn into the systems. There are many cases on record in which small fires in air duct systems have caused exceptionally heavy damage by smoke and hot gases being circulated through the air ducts to other parts of the building. To detect such fires quickly, photoelectric devices are installed which project a light beam across the interior of the duct. This beam is reflected back to a receiver, controlling devices which automatically close dampers, shut off fans, and sound warnings before any damage can be done.

Capacity-Operated Protective Systems

Electronic alarm systems of the body capacity type have come into extensive use in recent years for the protection of safes and metal cabinets, superseding the former method of inclosing them in electrically lined wooden cabinets which had to be especially built. With one electronic method, now in common use, a unit containing a vacuum tube oscillator is connected to the safe which is insulated from the ground. The safe and the ground form part of the electrical system and when the electrostatic capacity between these two elements is increased by a person or object approaching the safe, the balance of the system is upset and through the action of amplifying devices an alarm results.

This same principle has been applied in the last two years to the protection of outdoor areas such as property boundaries by connecting a similar unit containing a vacuum tube oscillator to field or "antenna" wires situated where the protection is desired and at the appropriate height above the ground. Since the electronic unit may be adjusted to detect the approach of a person to within a few feet of the antenna, protection is effective up to a height of several feet above the ground. On level ground the wires attached to insulators are supported on steel or wooden posts properly spaced to prevent sway. Closer spacing may be required over rolling ground. A single unit can provide protection for four or five hundred lineal feet of boundary. Any number of units can be operated without interference. Alarm signals of this type are received at a control center, usually by means of indicating target drops which show the particular unit that has been operated.

These electronic systems as applied to the protection of war industries are proving invaluable in supplementing watchman and guard forces, often providing a considerably higher degree of protection with less manpower. In many smaller plants and in certain buildings of large plants, these systems when combined with other automatic protection often are used to supplant watchmen entirely. This is desirable only when the systems can be connected to a central station where guards are constantly on duty to investigate and maintain continuous electrical supervision of the protection systems.

What the Future Holds

The foregoing outlines only briefly how electronics is being applied today in the field of industrial protection. Now, without going too far out on a limb, we will endeavor to take a look into the future.

It is generally admitted that prognostications may assume dangerous proportions and to attempt to foretell the future of protection services is perhaps no exception. Over the last 70 years burglar alarm systems have undergone tremendous development, and fire alarm and other electrical supervisory systems have kept pace. Therefore, it would be expected that with the coming of

(*Continued on page* 218)

INDUCTION HEATING

Comes of Age

Until recently best known among laymen for its therapeutic uses, induction heating has long been used in the manufacture of vacuum tubes. Now the principle is expanding rapidly into the general field of industry, accomplishing jobs which can be done in no other way

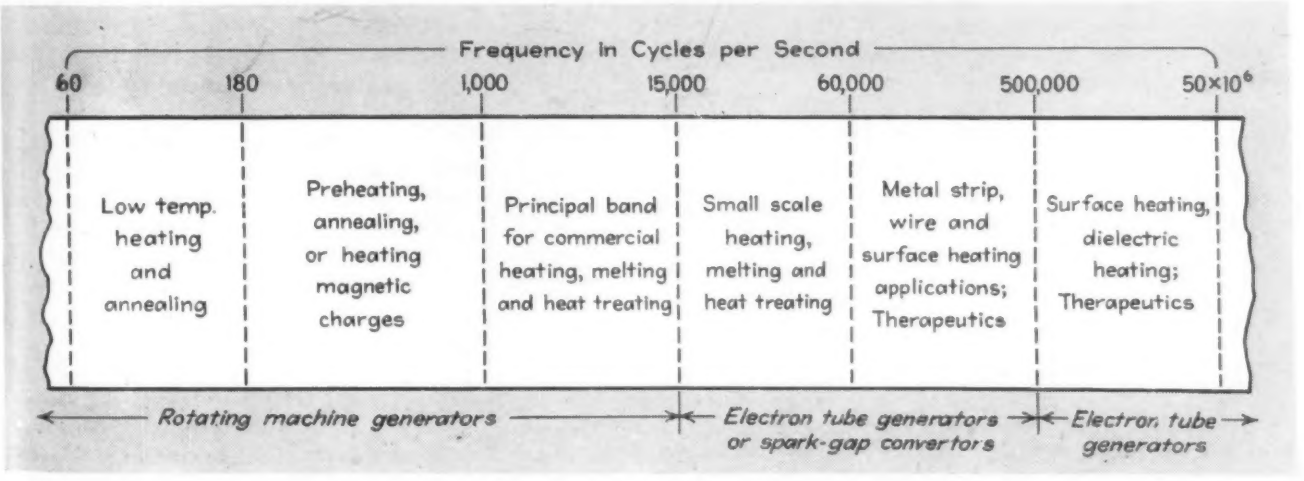
By G. W. PENNY
and J. A. HUTCHESON
Westinghouse Electric & Mfg. Co.

PLATING STEEL—The amount of tin required in the manufacture of cans may be reduced two thirds by electroplating sheet steel instead of dipping it in hot tin but the resulting finish is rough. A Westinghouse induction heating unit similar to this experimental electronic model runs the temperature of plated sheet up to 450 deg. F. causing the tin to flow and become smooth

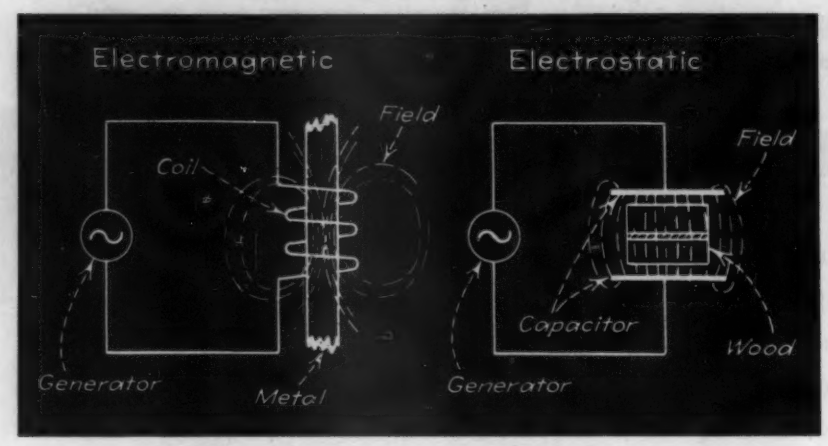
THE term "induction heating" has been applied to the process whereby any type of material is heated by the action of an electric or magnetic field in which the material is placed. For purposes of discussion, it seems logical to divide the subject into two categories, the first being that in which the heat in the material results from the action of an electromagnetic field and the second being that in which heat is produced in the material by the action of an electrostatic field.

The choice of the means of heating is usually determined by the characteristics of the material involved. If the material is a good conductor, such as the various metals, then it usually will be found that the electromagnetic field gives the best results. In an application of this type the object to be heated

SPECTRUM CHART OF INDUCTION HEATING



How Power Is Applied



Any material may be heated by placing it within an a-c electric field, inducing a voltage and causing sufficient current to flow. The field may be that surrounding a coil and this method of applying power is generally used where the material to be heated has relatively high conductivity. Or it may be the field existing between the plates of a capacitor, this method of applying power generally being most convenient where the material to be heated has relatively low conductivity

is placed in a coil of wire through which a heavy current is passing. The object therefore, is threaded by the magnetic lines of force produced by the current flowing in the coil and the alternation of the direction of these lines of force at a high rate induces a voltage in the material to be heated which, in turn, causes current to flow in the material. Presence of this current flowing through the resistance of the material produces a power loss which appears as heat in the material.

One of the earliest applications of this particular form of induction heating was made in the vacuum tube industry. In the manufacture of vacuum tubes it is necessary to heat up the elements within the tube in order to drive out any gas which may be occluded in them. This must be done while the tube is being evacuated, consequently it is not possible to accomplish this by external application of heat. The electromagnetic induction heating process was decided upon and has proved satisfactory for many years.

Other Types of Applications

Many other applications have been made of this particular type of induction heating. Some of these applications are currently in commercial use while others are still experimental. The following types of applications are typical:

(a) Heating vacuum tube elements.

(b) Heating crankshaft surfaces for surface hardening.

(c) Heating gears to provide surface hardening for the teeth.

(d) Heating tin-plated sheet steel to re-flow the tin.

(e) Heating rods prior to forging operations.

Applications of Electrostatic Heating

The electrostatic heating of materials has been, perhaps, more commonly known than the electromagnetic heating. It has been used for a number of years in demonstrations which have been shown to many thousands of people and which have aroused considerable popular interest. These demonstrations include popping corn and cooking the lowly hot dog by heat induced by electrostatic means. This process of getting heat in the material is usually applied to substances which are relatively poor conductors and which might more properly be classified as insulators. Such materials as wood, plastics, etc., come in this latter category.

The typical electrostatic induction heating apparatus employs a large capacitor in its load circuit which is made of two or more plates placed on either side of the material to be heated. The apparatus usually operates at a frequency higher than that used in the electromagnetic type of induction heating equipment.

The application of the electrostatic type of induction heating equipment has been more varied than the electromagnetic type. There are applications of the type where heat is produced in materials such as plastics for the purpose of melting them. In other applications the heat is generated to hasten the drying of the material, such as wood or certain types of plastics. One example of this type is found in the application wherein a glue used to fasten two large surfaces is heated and dried by electrostatic induction heating. This results in considerable saving of time. Another class of application is made in certain cases where small insects or larva which are present in a host material are killed by passing them through a high frequency electric field. In this case it seems that death is brought about by heat generated in the insect itself. Still another type of application is that wherein heat is produced in a material for the purpose of changing the characteristics of it. Roasting peanuts is a good example of this type.

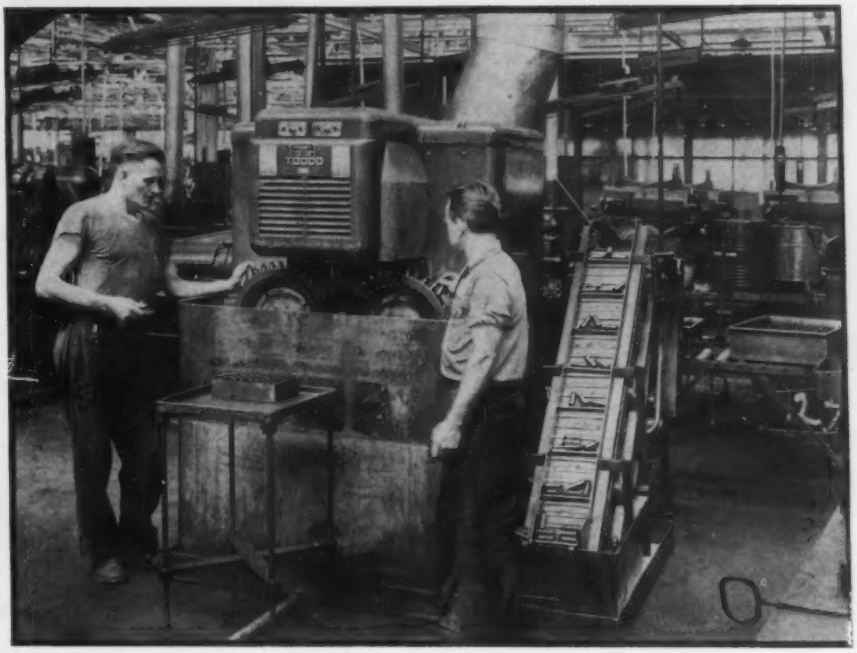
One type of induction heating which may be either electromagnetic or electrostatic in character is the fairly well known "radio therapy" equipment. The problems involved in this medical apparatus are well known and have been dealt with in other papers, and therefore will not be described further here.

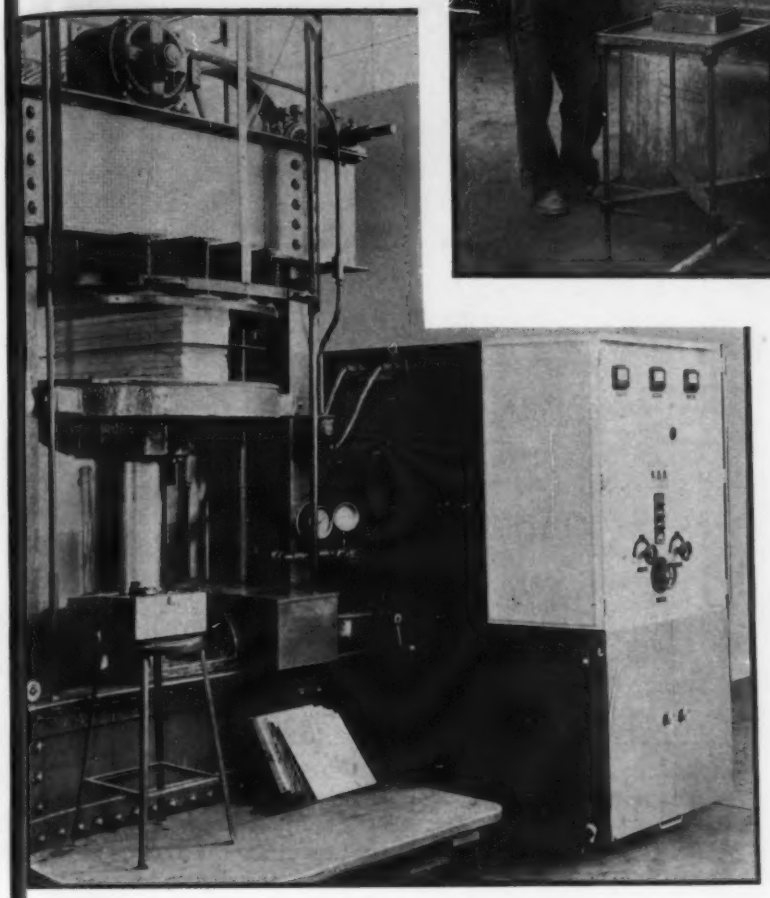
The main characteristic of induction heating rests in the fact that the heat desired is produced directly in the place it is needed. This feature works advantageously in applications of the type where the material to be heated is not accessible, such as the elements of a vacuum tube. It is also advantageous in applications where otherwise heat has to be transmitted through other material.

Induction Heating Apparatus

The apparatus used for producing this radio-frequency power for use in heating by induction is com-

aratively simple. Fundamentally, it comprises a rectifier to convert commercial frequency power into direct-current power and an oscillator to convert the direct-current power into the desired radio-frequency power. The primary considerations in the design of this equipment are maintenance of continuity of operation and simplicity of operation



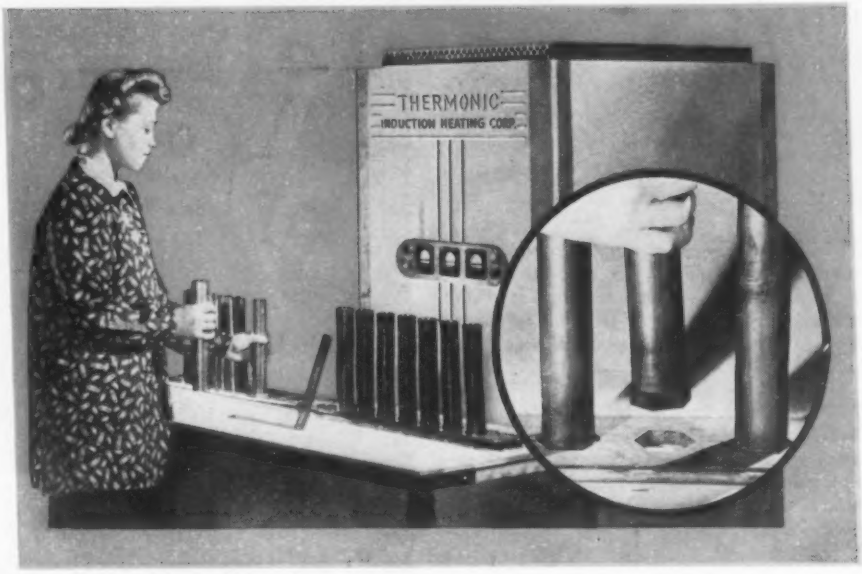


HARDENING METAL—(Above) This "Tocco" rotating machine type of generator turns out 3000-cycle power used to heat metal parts to 1500 deg. F, handling 70,000 per day. Not all induction heating apparatus employs tubes but continuation of the trend toward higher frequencies brings more and more of them into use

BONDING PLYWOOD—(Left) This medium-size, tube-type industrial heating unit built by the Girdler Corp. delivers 7 kw of high frequency power and is shown operating in conjunction with a developmental press in a plywood manufacturer's laboratory. Similar units turning out 600 kw or more have been built by the same company and are in use

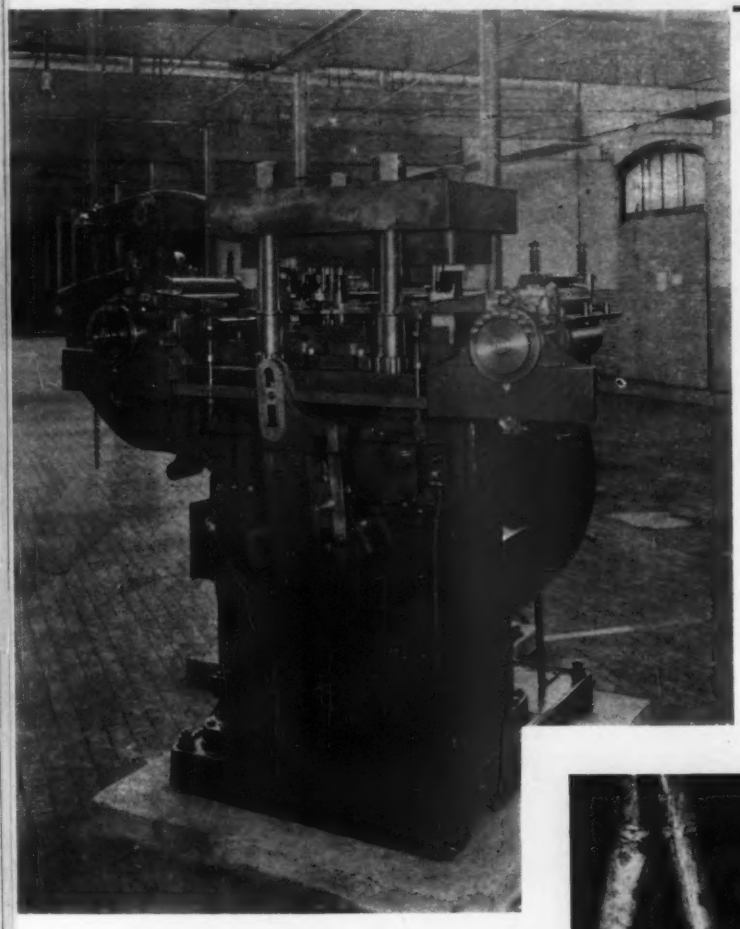
BRAZING BOMBS—(Below) Here an Induction Heating Corp. electronic unit brazes the nose assemblies of seven 4-lb. incendiary bombs at once, single-turn power applicator coils raising the temperature to 1150 deg. F in 70 seconds

to provide satisfactory service in the hands of inexperienced operating personnel. The frequencies used vary from about 15 kilocycles to 50 megacycles. This range does not impose any new problems to the designer. The power level is usually high, being in the order of hundreds of kilowatts. In this connection it is interesting to note that the total power used for radio-frequency induction heating today is probably in the order of 10,000 kw. (Editor's Note — Total installed power in broadcast stations in the U. S. is about 4,000 kw.) A single installation employing 3,600 kw is in the process of construction as this paper is being written.



PRODUCTION CONTROLS aid the War Program

By using high-speed electronic devices to inspect parts of all kinds as they leave production lines, manufacturers of components are saving themselves and assemblers much time and material. Electronic gear is also helping to lengthen the life of many machines



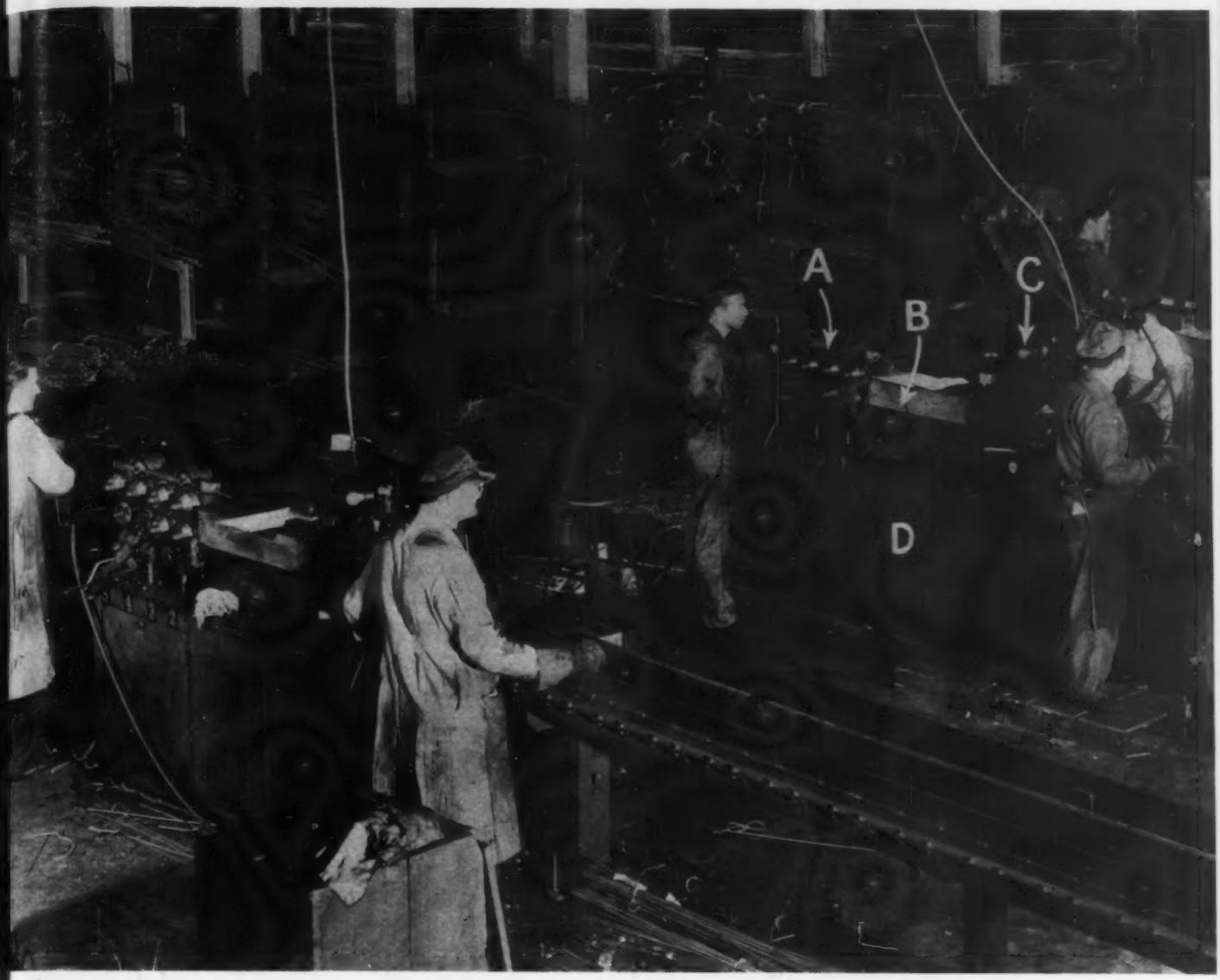
PROTECTION — High-speed progressive punching machine of the type discussed by the author. Phototubes are used to make certain that metal strip fed to such machines is uniform to prevent breakage of dies

PROCESSING—Tubing is here fed into 240 kc induction heating apparatus which anneals the tips and facilitates later operations. The hood over the hairpin coil which applies power is used to carry away gases

By RALPH A. POWERS

Bundy Tubing Company

ELECTRONIC EQUIPMENT is obviously playing an important part in the war production program. It is speeding up communications between government agencies and plants, between primary contractors and sub-contractors and between departments in individual factories. It is protecting plants against fire, explosion and burglary and, particularly, against deliberate acts of sabotage. It is safeguarding the arms and legs of workers operating machines under "forced draught." It is providing automatic control so that machines of many varieties may



INSPECTION—Two electronic flaw detectors at work at Bundy Tubing Co. automatically marking steel tubing at the rate of 300 feet per minute. A—Marking rollers operated by tube equipment. B—Magnetic unit with three balanced pickup coils. C—Pilot lamp assembly to indicate operation of equipment. D—Location of amplifiers and other electronic equipment

chieve a maximum rate of production with a minimum of human attention.

Electronic equipment is doing at east two other vital jobs in industry and these are our specific concern here. It is checking the quality f manufactured parts destined for se in critical gear as these parts eave production lines and it is protecting the precious machinery hich turns parts out. Examples are oo numerous even to list but we can escribe a few applications and so ndicate the general trend.

Detecting Tube Flaws

With the ever increasing use of razed or welded tubing for gasoline ines, oil tubes and control lines, uch tubing must be rigidly inspected for flaws in the brazing or welding operation as well as for flaws in the metallic structure itself. Voids between laps, in the case of multi-lapped steel tubing, must also be detected and rejected.

Electronic flaw detectors have been developed to accomplish rapid and automatic inspection of tubing. Tubing passes into a straightening device, then through "saturation" and "pickup" coils and out the other end of the test machine at the rate of 300 feet or more per minute. In the event a flaw is detected by electronic equipment located in the base of the machine an air-cylinder operates a crimping device which automatically marks the tubing at the location of the flaw.

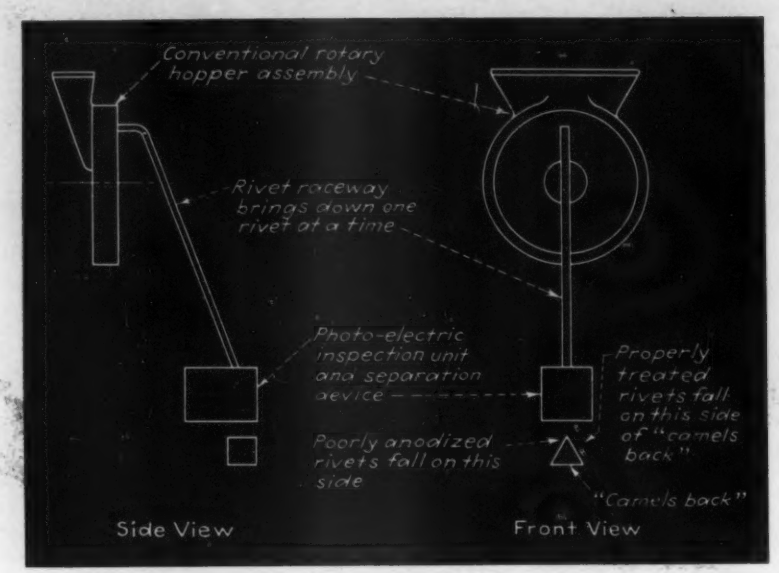
This same general type of high frequency, or magnetic, detection of flaws is being considered for steel bar stock used in automatic fabrication of other critical metal parts which must be made as flawless as possible.

Rivet Inspection

Recently, the problem of high-speed inspection of rivets came up in an important manufacturing plant. Thousands of rivets had to be inspected to see if they were properly "anodized". Electronics solved this problem.

After anodizing, the rivets are put through a dying process. Those that have been properly anodized change color to a dark green, while those that have received insufficient anodizing appear grayish in color or

HIGH-SPEED ELECTRONIC RIVET INSPECTOR


Conventional rotary hopper assembly
Rivet raceway brings down one rivet at a time
Photo-electric inspection unit and separation device
Properly treated rivets fall on this side of "camels back"
Poorly anodized rivets fall on this side
"Camels back"
Side View
Front View

Poorly anodized rivets reflect less light from a lamp to a phototube than properly finished rivets and the resulting difference in phototube amplifier current operates a switch. The switch actuates an electromagnetic hammer, or a valve controlling an air-jet, in such a way that defective rivets are flicked or blown to one side as they leave the raceway

merely appear to be lacquered a transparent, slightly yellowish, color.

Following the general principle of photoelectric bean-sorting and rocksalt sorting, the difference in reflected light between rivets that have been properly anodized and those that have not been properly anodized is sufficient to permit detection and automatic sorting.

One of the major problems was to handle the large number of rivets per hour. This required a suitable means of hopper-feeding rivets so each individual rivet could be "scanned", or looked at, by a phototube and its associated amplifying equipment. The standard procedure is to use conventional rivet-hoppers of either the rotating type or the vibrating type, so that rivets fall in line and pass down a common raceway to automatic riveting machines. Photoelectric detection apparatus is installed at the end of this raceway.

Various types of ejection mechanisms can be used. These include high-speed solenoid air valves to blow the rivets to be rejected out of the way and high-speed hammers of the dynamic type, with suitable equipment for damping oscillations.

Protection of Dies

Where parts are stamped out of metal strips by high-speed presses, dies are frequently damaged due to irregularities in strip width and thickness and, particularly, non-uniformity of the metal with regard to hardness. Where fabrication of the metal strip involves lamination or welding prior to the performance of the stamping operation breakage of dies is particularly troublesome.

Such troubles are now minimized by "scanning" the width and thickness of metal strips by means of light-beam and phototube units as the strips pass to the press between guide rollers, the press being automatically stopped where material width or thickness is apt to cause die breakage. Unusually hard spots in metal strips caused by bad welds generally show up as black specks in the metal and the difference in the amount of light reflected from such specks and adjacent metal is readily detected by means of light-beam and phototube apparatus, again permitting the press to be automatically stopped before such hard spots reach the dies.

In certain industrial applications of high-speed die presses four or five separate light-beam and phototube units are used in the manner discussed above, all of these units being connected to a common vacuum tube amplifier in such a manner that almost any abnormal metal strip characteristic causes the press to be stopped before the metal reaches the dies. Similar safeguards are also included in some instances to prevent operation of the press in the event that pieces of metal fail to reject properly from either the male or female member of the die.

Induction Heating Control

When vacuum tube oscillators are used either for annealing materials or for continuous brazing, electronic time delays systems frequently control cyclic functions of the complete machine. Tube time delays may, for example, be arranged so that water cooling can be automatically turned on several minutes before heating starts. Water may also be left on for a definite period of time after the equipment has been turned off at the end of an operating cycle.

When annealing at high frequencies the ends of small pieces of monel or standard steel tubing such as that used for gasoline engine radiators, induction heating is incorporated within an automatic machine. Electronic time delays control the sequence of the machine, which forces short lengths of steel tubes through the induction heater and coils and, after required heating time, directly into a swedging operation which makes hex sections on the ends of the round tubes. Electronic time delays are used to insure that the gas in the hydrogen chamber has been turned on prior to starting of the process described and are also used to be sure that the tubing cannot be started from the rolling machines through the induction heater until preceding work has been cleared.

INDUSTRIAL APPLICATIONS

Involving Electronic Detection

By **ABRAHAM EDELMAN** *Photobell Corporation*

BALANCE — Westinghouse trues up electric motor rotors by running them in this electromagnetic unbalance detection machine using a vacuum tube amplifier

MANY of the most useful applications of electron tubes to industrial problems involve the simple fact that all such tubes can be made to act as *detectors* of the presence or absence of an object or of some characteristic of an object, or of certain physical changes in the object. For example the "electric eye"—popular term for the phototube—is a detector of light. A beam of light "detected" by a phototube is converted into an electric current. The ordinary tube as used in millions of home radio sets acts as a detector of electrical quantities, such as voltage, current power, etc. The Geiger-Müller tube, for example, is a detector for cosmic rays but has been put to numerous mundane uses. Its principle of operation differs markedly from that of either the phototube or the radio tube (which is essentially an amplifier)—but all three are electron tubes; and all three find use in industry.

It is but a step from *detection* of some physical change in an object or material to the *control* of the physical characteristics of that object or body. Thus in the recital to follow, of several uses of the phenomenon of detection, certain adaptations could make the detection system also act as a controlling system.

The Tube as a Detector

The ordinary radio tube requires that the device or characteristic to be detected produce a voltage change at the input to the tube. Therefore, there usually must be some sort of conversion device between the stimulus and the input to the tube. As a simple and most useful example, a microphone can be placed in the vault of a bank. This microphone is a device which converts sounds into voltages. Any intrusion into the vault, or even any intrusion on its surroundings may produce a noise which the microphone translates into a voltage which is amplified to any desired degree by an electron tube amplifier.

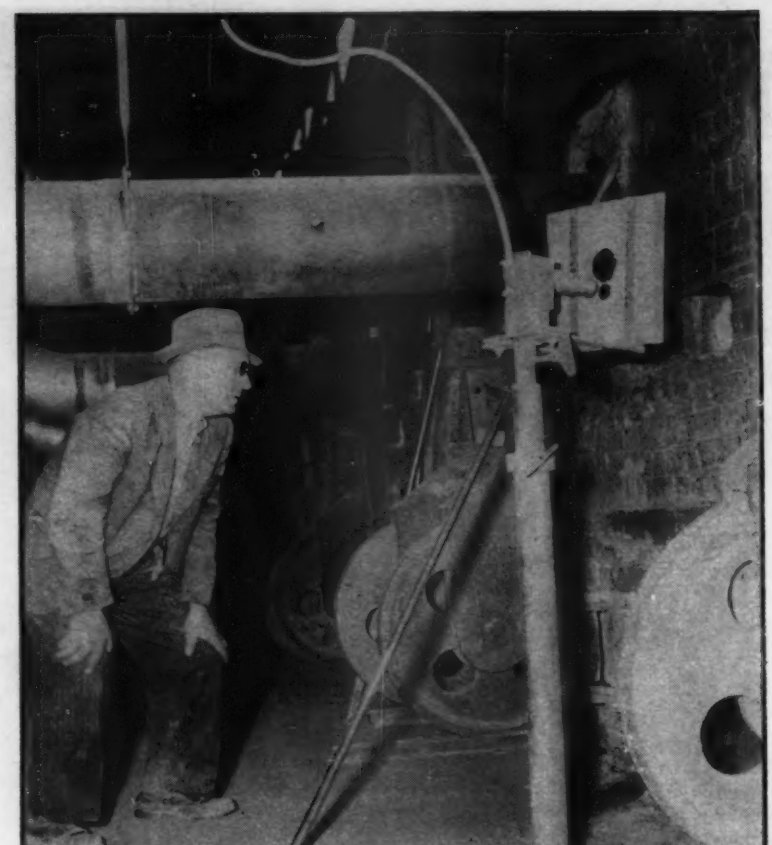
Another interesting application of the microphone-amplifier combination is its use to test the soundness of castings and forgings. The work to be tested is struck with a hammer and caused to vibrate audibly. A microphone picks up the sound, amplifies it and filters out harmonic frequencies so that the base frequency may be compared with a standard tone. Experiment has shown that a defective part will not vibrate the same as a good part and this furnishes a suitable basis for comparison.

Another electronic method for detecting soundness of work is frequently used for checking the perfection of seam welds. The weld is caused to pass directly under a coil through which high-frequency current is passing. This generates eddy currents in the welded parts, through the welded seam. As the seam passes under the coil, the eddy currents remain sensibly uniform until an unwelded portion is reached, whereupon the eddy currents are reduced because of the high resistance or partly open circuit encountered. When eddy current is reduced, a bridge circuit unbalances and an indicator or alarm operates.

The very fact that a tube will pick up radio programs out of the air indicates an interesting application. Broken insulators on power lines create sparks; these sparks act as miniature radio transmitters; a radio receiver in the vicinity will pick up these spark noises and by proper orientation of the antenna indicate the location of the broken insulator or other source of leakage of power.

Metal Detection

Electron tubes are widely used to detect metal. An early use was in prisons or other places where it was



TEMPERATURE—G-E phototube holder and optical system, trained into cement kiln for temperature control at Nazareth Portland Cement Company

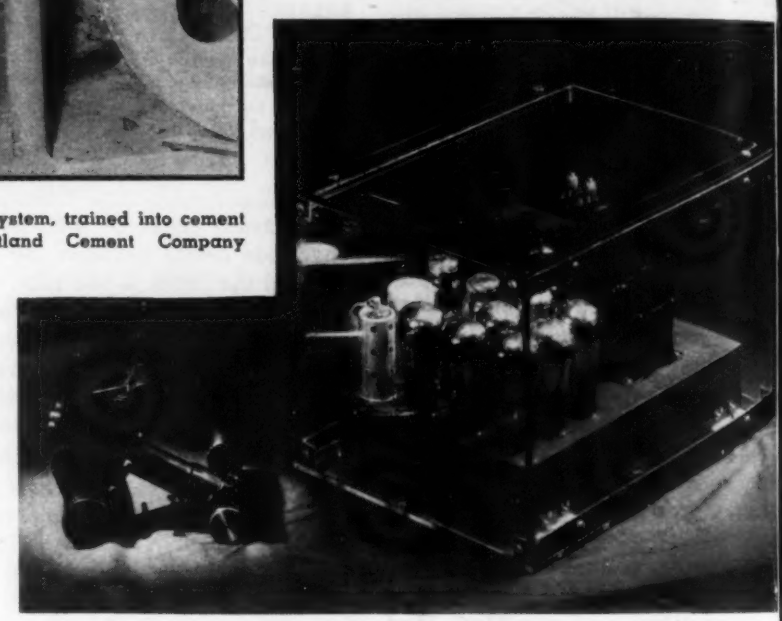
undesirable for any metal to be transported across a doorway. Any metal hidden on a person traversing the doorway can be detected without his knowledge or consent by simple electronic methods. The metal detector widely publicised because of its employment to locate shrapnel in the bodies of sneak attack victims at Pearl Harbor is another example. Somewhat similar devices have been utilized for locating metal underground, such as water pipes, or mineral wealth, or buried treasure. Similarly, metal detectors are employed to discover unwanted metal in furs and skins, rubber, paper and other materials handled in bulk.

In the manufacture of paper for employment as punched cards in tabulating machines it is important that there be no imbedded metal particles in the paper, because such particles will act in the same fashion as a punched hole, conduct electricity through the paper and so furnish a spurious operation. Metal particles enter the paper mash during its manufacture, often coming from the metal beaters which are used. To combat this difficulty, the paper is passed through a machine in which metal brushes rub against the paper. Although the paper may be travelling at speeds up to 400 feet per minute, a particle of metal capable of passing a micro-coulomb of electricity operates an amplifier connected to the metal brush; this energizes a relay and operates an inking device which makes a long ink stripe on the paper starting at the metal particle and extending for several feet. Later, when the cards are all complete, it is easy to find these stripes by looking for them along the cut edges of the piled up cards.

In most or all of these cases where a tube is used to detect presence of objects unseen, or changes in the characteristics of a material, the tube translates the voltage stimulus placed upon it into a current or power change. This change in an electrical current may be indicated on a current-reading meter, or it may be used to supply power to operate a relay. The relay may turn on a light, ring a gong or perform any other desired function.

Capacity Relays

A combination of tubes and simple electrical or mechanical parts in proper fashion produces what is termed a "capacity relay." The electrical capacitance between two metallic objects insulated from each other, or between one such object and the ground, will change when the objects are approached by any person or object. This change in capacitance can be converted, by the amplifier tube, into an audible or visual alarm.



COLOR—Rock salt sorting device utilizing a phototube detector and a vacuum tube amplifier. Rapidly distinguishes variations in color, or size, or both

The application to a jeweler's showcase is obvious. Similarly capacity relays have been employed to open electrically-operated doors in locations at which phototubes could not operate; and to start a powde

falling into a metal-foil lined paper bag when the bag has come into position under a spout from which the powder pours. A capacity relay performs a unique service by filling glasses properly. Two metal plates forming the capacitance are placed outside the glass in a machine intended to dispense milk at a school. A pump drives the milk into the glass, between the two plates, at a constant high speed until the capacitance between the two plates has increased to a value which operates a relay to stop the flow of milk. In addition to being absolutely sanitary, this method is faster than the previous methods, in which the milk was caused to seek its own level by a syphon system.

Instead of using capacitance, the electric field existing between two coils carrying an electric current may be utilized as the detecting agent. If the two coils are insulated from each other and made to form a part of an amplifier or oscillator circuit, any metallic object interposed between the coils will change the tube current and will operate a relay.

DUST—Electrostatic precipitators designed to rid air of dust and dirt use electronic principles, are more efficient than mechanical filters

High-speed Counters

Any of the methods outlined briefly above can be made to count objects by the simple expedient of using an electromagnetic counting device instead of a relay in the output of an electronic amplifier. Each time a tube gets an impulse on its input, the output current change will operate the counter.

Electron tubes are useful in all these applications for several reasons. For example, a tube requires practically no energy from the stimulus to make it work. Thus a tube will operate from sources of stimuli in which extremely little power exists. Yet, interposed between such a source of stimulus and a power relay, the tube acts as a power amplifier, increasing the original power to the point at which it will operate a relay.

Another reason why the tube is so important is the fact that it requires practically no time in which to operate. This is because the electrons traversing the tube have so little mass they can be accelerated to very high speeds in extremely short spaces of time.

For example, the usual mechanical counting machine will operate several hundreds of times a minute successfully. Electronic counters, on the other hand, will readily respond to half a million or more counts per minute. An interesting system has been developed for causing such an electronic circuit to operate a standard slow-operating counting unit. This consists of a circle of tubes so interconnected that the impulses to be counted reach all of them symmetrically. At any one impulse, only one of these tubes responds; and its response is such that it primes the next tube in line so that the latter will respond to the next impulse. Thus, each succeeding impulse causes the response to occur in another tube within the ring of tubes. There may be any number of tubes in a ring; for convenience, assume that there are ten. Then any one tube in the ring will operate from one tenth of the total number of pulses. The tenth tube is also connected to a second ring of ten tubes in such fashion that it furnishes the impulses to this entire ring. As a result, each tube in the second ring operates from one pulse in each hundred. A relay in the output of the final tube, therefore, operates on every hundredth impulse, and must operate only one hundredth as fast as if it actually recorded each and every impulse. It is just as accurate, however, as if each individual impulse caused the final counter to operate.

The high speed of operation of amplifier tubes has provided the means for an effective *precedance relay*, which can tell which of two events happened first, even though the time interval between the two events may be very short.

Phototube Detection Systems

Since a beam of light shining into a phototube causes the latter to produce an electric current, which can be amplified in the types of tubes just described, it is only natural that detection or counting systems have been devised which utilize the flexibility of a light beam. All that is necessary is to shine the beam of light, invisible or visible, across the path along which the objects to be counted are passing. Each time the object eclipses the beam of light, the electric current from the phototube is interrupted, this change in current is amplified by the following tubes and caused to operate a relay or counting machine.

Phototubes can be used with colored filters so that they are responsive to certain colors and not to others. Then objects having the two colors, one for which the tube is sensitive and one for which the tube does not respond, may be separated or counted separately by a phototube-amplifier system.

Since the electric current generated by the phototube is in direct proportion to the amount of light shining on the tube, the phototube

Electronic Equipment used by

THREE MAJOR INDUSTRIES*

ELECTRICAL MANUFACTURING

COMMUNICATIONS

- Radio receivers
- Intercommunication systems

CONTROL and PROCESSING

- Welding timers
- Temperature controllers
- Flame controls
- Smoke detectors
- Electronic switches
- Vacuum tube relays
- Induction bombarders
- Balancing machines
- Bactericidal lamps

MEASUREMENT

- Cathode ray oscilloscopes
- Vacuum tube voltmeters
- Signal generators
- R-C oscillators
- Beat frequency oscillators
- Square wave generators
- Tuning fork drivers
- Wave analyzers
- Sound meters
- Stroboscopic devices
- Capacitance bridges
- Megohm bridges
- Vacuum tube electrometers
- Time gauges
- Integrating flux meters
- Electron microscopes

MISCELLANEOUS

- Vacuum tube amplifiers
- Constant voltage power supplies
- Mercury vapor rectifiers

PETROLEUM FIELD

COMMUNICATIONS

- Radio receivers
- Radio transmitters
- Ship to shore equipment
- Land line repeaters
- Public address equipment

CONTROL and PROCESSING

- Electronic timers
- Vacuum tube relays
- D-C motor speed controls
- Temperature controls
- Welding controls
- Specialized locating equipment
- Specialized well-shooting equipment
- Sonic fluid level indicators
- Seismograph recording equipment

MEASUREMENT

- Cathode ray oscilloscopes
- Strobescopic devices
- Vacuum tube voltmeters
- Recording type impedance meters
- Recording type low potential meters
- Signal generators

MISCELLANEOUS

- Amplifiers
- Rectifiers
- Geophones

MACHINERY MAKERS

COMMUNICATIONS

- Radio receivers
- Carrier current relays
- Carrier current telemetering
- Public address systems
- Intercommunication systems
- Sound recording equipment

CONTROL and PROCESSING

- Welding timers
- Alternator controls
- Temperature controls
- Electronic switches
- Vacuum tube time delays
- Photoelectric relays
- Conveyor controls
- Induction heating equipment

MEASUREMENT

- Bearing noise testers
- Mechanical movement recorders
- Densitometers
- Score testing devices
- Cathode ray oscilloscopes
- Vacuum tube voltmeters
- Sine wave oscillators
- R-C oscillators
- Beat frequency oscillators
- Megohm bridges
- A-C bridges
- Recording microammeters
- Sound level meters
- Wave analyzers
- Stroboscopic devices
- Surface analyzers

MISCELLANEOUS

- Audio amplifiers
- Electronic voltage regulators
- Rectifiers

* Partial list from an editorial survey of typical companies

be used as a measure of the ount or intensity of light im- ssed upon the tube. Many thou- ds of light-measuring instru- nts and photographic exposure ters in use furnish sufficient evi- ce of the success of this type of trument.

Photoelectric devices are most quently used where *seeing* has en the essential task; and at the ment there are more of these tine jobs being taken over by tronic devices than the casual der would imagine. Photoelectric ipment is now being used to nt cartons, to route them accord- to size or shape or color or ight, for inspecting them to see if per labels have been affixed, for chronizing the flow of work be- een machines; and in literally ousands of similar tasks.

Detection Extended to Control

Since electron tubes can be made detect presence or absence of ob- ts or changes in the characteris- s of materials, and will operate an rm when certain undesired anges occur, it is only a simple ventive step to realize that the rm can be made to perform a more eful task than merely to inform an erator that something has gone ong. Instead of the audible or ual alarm, one may use a valve which turns on or off water, or steam, or a flow of any material or one may perform practically any other *control* function desired. These systems may be made self-monitoring so that when something goes wrong with the system, no damage occurs.

Detection devices are frequently capable of replacing personnel; and in times of labor shortage as at present, their value may not be measured in terms of money alone. There are many jobs being done electronically and automatically today that were formerly accomplished less efficiently by manpower, as some of the following examples will show. The trend today is toward fully automatic machines where previously it was toward machines with operators to feed something here, adjust something there. It is no uncommon sight inside a progressive factory to find assorted machines working away unattended, at tasks that personnel could do only with experience and attention of a high order. The electronic robots of our present-day factories are enormously increasing the war effort, without fatigue or wage.

An entire class of such devices may be described by furnishing an example. A factory employs a large, complicated machine to manufacture very large size bags by cutting the paper from a roll, folding it up, and gluing it together. Various causes make the paper jam up in the machine occasionally; sometimes the paper is imperfect, at other times the humidity is to blame. An operator is required to watch each section of the machine, and instantly to press a stop button when something goes wrong. If the operator is not fast enough, then the bags wrap themselves around parts of the machine, and cause considerable damage. To correct this situation, photoelectric devices have been installed to replace the watchers. They shut off the power instantly if the bag does not show up during its allotted time at the right place between certain rollers, and sound an alarm so that no time need be lost for the difficulty to be corrected and the machine restarted.

The layman is familiar with the photoelectric door operator, which causes the door at a railroad station, hotel, showroom, restaurant, etc., to open as someone approaches it. This apparently personal attention is usually obtained through the agency of three photoelectric devices and their associated equipment. A beam of light is intercepted as a person approaches the door, and this causes the door to open. Some people may stop in the doorway or walk slowly, and therefore a second beam of light is provided in such position as to be intercepted during the entire time that the person is passing through. Finally, a third beam of light is provided so that it will be intercepted when the person has fully passed through the door, and is departing. This initiates a closing operation for the door. Many design details have been improved in these doors through the years of experiment with them, so that today they are quiet in operation, free from operating troubles to a large extent, and are not a hazard to the pedestrian in any sense.

The layman probably does not know that there are far more doors of this type employed to save time and money than there are for luxurious atmosphere. Restaurants were among the first to recognize that waitresses could use them to great advantage in passing between kitchen and dining room. Today, the noise and odors of the kitchen are kept out of the dining room while

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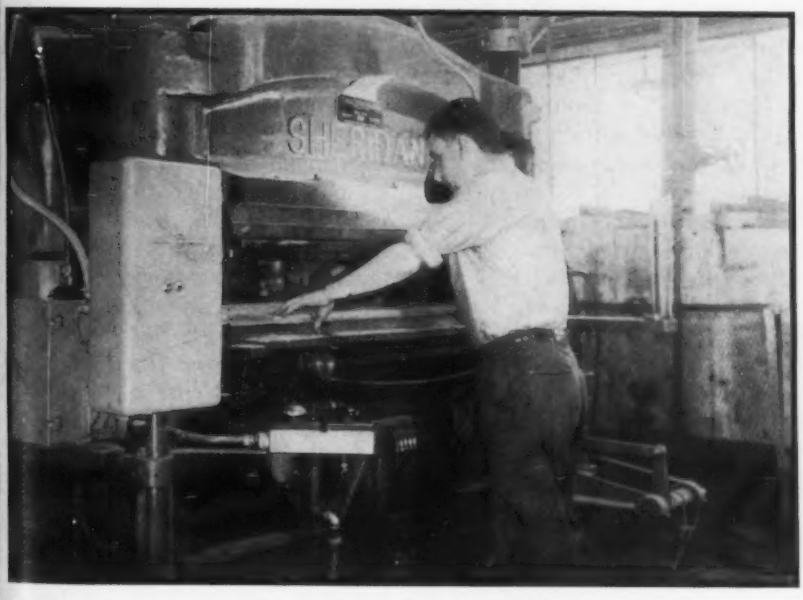


DETECTOR—Here an Electronic Control Corporation device using phototubes prevents operation of an embossing press if the operator's arms are in danger

POWER COMPANY
Uses of Electronic Equipment

Tubes probably find a wider variety of applications in the electric utility field than in any other. Virtually every function they can perform is utilized in one way or another. Data concerning this particular industry is, therefore, especially informative

THE electron tube has been accepted with enthusiasm by the electric power industry. Things are done in power systems through the use of tubes which were formerly impossible or at least inefficiently accomplished by other means.

The demands placed upon the field of electronics by the power industry are extremely varied and cover a wide range of power handling requirements. There are many applications for sensitive and weak current devices on the one extreme while on the other extreme we find mercury arc rectifiers and frequency converters handling thousands of kilowatts. The weak current devices are represented by photoelectric controls, synchroscopes, relays, communication equipment, amplifiers and many other specialized designs. The medium power class of equipment is along the line of automatic battery chargers, voltage regulators and exciters and governor controls for the large power station generators. In the heavy power bracket falls the controlled mercury arc rectifiers and also frequency changers for converting large amounts of power from one frequency to another for more efficient use of the power on electric traction systems. The grid controlled rectifier is rapidly replacing rotary converter equipment in many phases of the power field. The ease of voltage control and the speed of response to the control is superior to rotary machine operation. Those of us who have been most closely associated with the low power applications of tubes have a tendency to overlook the fact that these high power tubes are true electronic devices and are fundamentally the same as the small and popular types. It is true that the large tank-type mercury arc rectifiers do not resemble the familiar form and appearance of the regular tube, yet many of the design difficulties were overcome in the small types, thus making the large ones successful. The success and reliability of operation provided by the smaller types of tubes have been the incentive for the wide adoption of tubes, both large and small.

Factors Affecting the Adoption of Tubes

The general acceptance of electronics in power systems has been impeded because in power work the old equipment has, in most cases, been doing a good job for many years and would be expensive to modernize. With machinery which has been designed to work with the electronic control circuits the full advantages are obtained from the new circuits, and the original installation is made with the goal of maximum over-all efficiency in mind. However, since much of the equipment in use today was installed before the electron tube was considered to be useful in power systems, the process of adapting this older equipment to new control circuits becomes more difficult. There have been some installations on the old machinery to help make up for the shortcomings under the steadily rising standards of operation. These additions which have resulted in more accurate frequency control, closer and faster voltage regulation and other advantages obtained through the use of automatic controls and telemetering, are possible only by employing the sensitive and inertialess electron tube.

Another factor which slowed up the acceptance of tubes by power systems has been the natural and justified reluctance of power engineers to the use of the new equipment. The tube has had to prove that it is out of the gadget stage and is now in a position to take over responsible applications without danger of fail-

TYPICAL APPLICATIONS *

WEAK CURRENT

- Radio transmitters
- Radio receivers
- Carrier-current transmitters
- Carrier-current receivers
- Carrier-current relays
- Carrier-current switching equipment
- Telemetering of voltage
- Telemetering of current
- Telemetering of wattage
- Telemetering of pressure
- Telemetering of temperature
- Telemetering of water level
- Telemetering of frequency
- Location of cable faults
- Location of pipe faults
- Control of phase-angle
- Control of loads
- Alarms for over-voltage
- Checking of wattmeters
- Protection of property . . . . . .

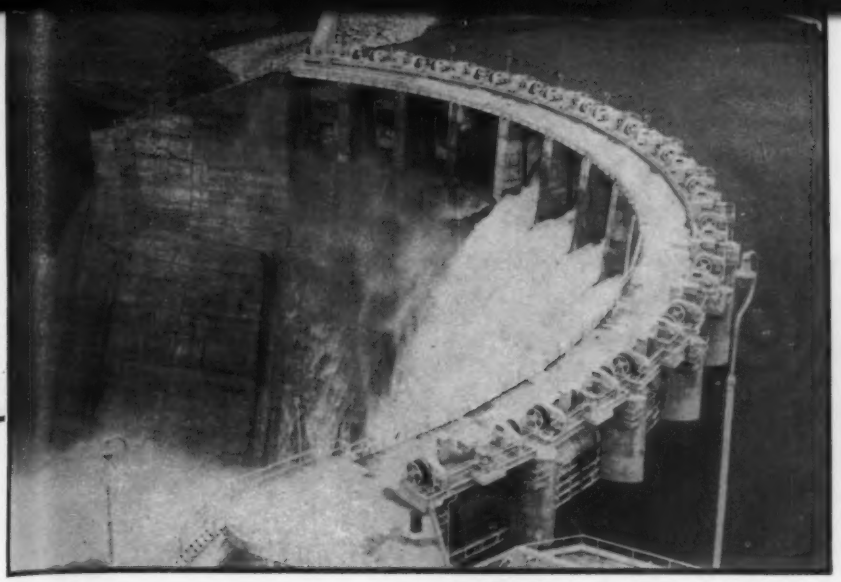
MEDIUM CURRENT

- Charging batteries
- Testing cable
- Testing insulation
- Testing rubber gloves
- Regulating voltage, current
- Exciting generators
- Eliminating smoke . . . . . .

HEAVY CURRENT

- Mercury-arc rectification
- Frequency conversion
- Electrolytic processing
- D-c transmission . . . . . .

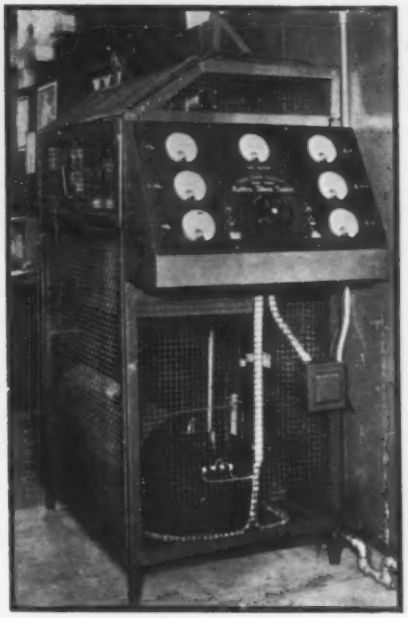
*Partial list.

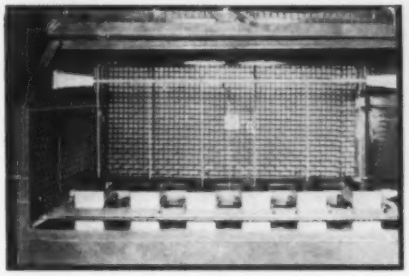


CONTROL—Electronic governors open and close gates at this power dam

By W. H. BLANKMEYER

The Montana Power Company





SAFETY—Rubber glove tester designed by Leonard W. Walker of the Idaho Power Company. 15,000 d-c. volts is applied in series with a milliameter and when leakage exceeds a safe value the gloves are discarded. Contact is made by filling gloves with water and then partially submerging them in water, chains lowered into the water within each glove constituting one connection and the tanks the other connection. Six gloves may be tested at once

ure or of excessive maintenance. With regard to the maintenance factor, experience has shown that the maintenance of electronic equipment is usually less than other types of equipment doing the same job. Also it is easier to avoid future trouble in electronic equipment through periodic testing than by inspection of regular old style equipment.

A third factor which slowed the development of the field was the tube licensing situation. The tube patents were so interlocked that it was impossible for any one manufacturer to build tubes and equipment for power system use without infringing on several other patents. Consequently, development was almost at a standstill until the exchange of several patents cleared up this difficulty to every one's satisfaction.

Development of Electronic Applications

In the early days of electric power generation and distribution it was not practical to transmit power over great distances. The generating plants had to be located at or near the load center and a sufficient number of plants provided in the densely populated areas so that the power need not be transmitted far.

The operation of such plants as compared with present day problems was comparatively simple. It was not necessary to employ complicated protective relay systems, communication networks, telemetering and numerous other modern devices to maintain the required standards of customer service. This ease of operation was partly due to the fact that there were but few industrial loads so that a short power outage was not a serious occurrence. However, during the time of these early systems a need was felt for many of the modern developments.

The development of the long distance high voltage alternating current transmission line changed the entire picture of the power system. The electric power could be generated at the source of water power or near a conveniently available fuel supply. This major developmnt complicated the power system enormously. For example, it became necessary to have some form of communication system to carry load dispatching orders, line clearances to facilitate repairs and for routine business conversations.

The telephone and telegraph lines provided the only communication along these early day transmission lines. The telephone conductors were generally supported on the same pole or structure as the power conductors. The result of this practice was that the tight coupling with the power circuit caused such a high noise voltage to be induced in the telephone circuit that it was usually impractical to maintain high standards of transmission. This noise and the high long-line attenuation can now be overcome by the use of high level audio transmission using special amplifiers and repeaters, or by employing carrier current.

Another power system complication resulting from the change to long transmission lines was the need of adequate equipment protection in the form of automatic switching. Long transmission lines are extremely vulnerable to lightning, sleet, wind, floods, etc.

When a phase to phase or phase to ground flash-over occurs on a high voltage line a serious disturbance occurs which must be cleared very quickly to prevent damage to the associated equipment and to prevent a general shut-down. This automatic clearing is accomplished or aided economically and efficiently by the use of a carrier signal.

In the event of a disruption of the power line it usually means that the telephone line is also put out of service, since they are both mounted on the same structures. To alleviate this difficulty it is now common practice to provide lines over which both

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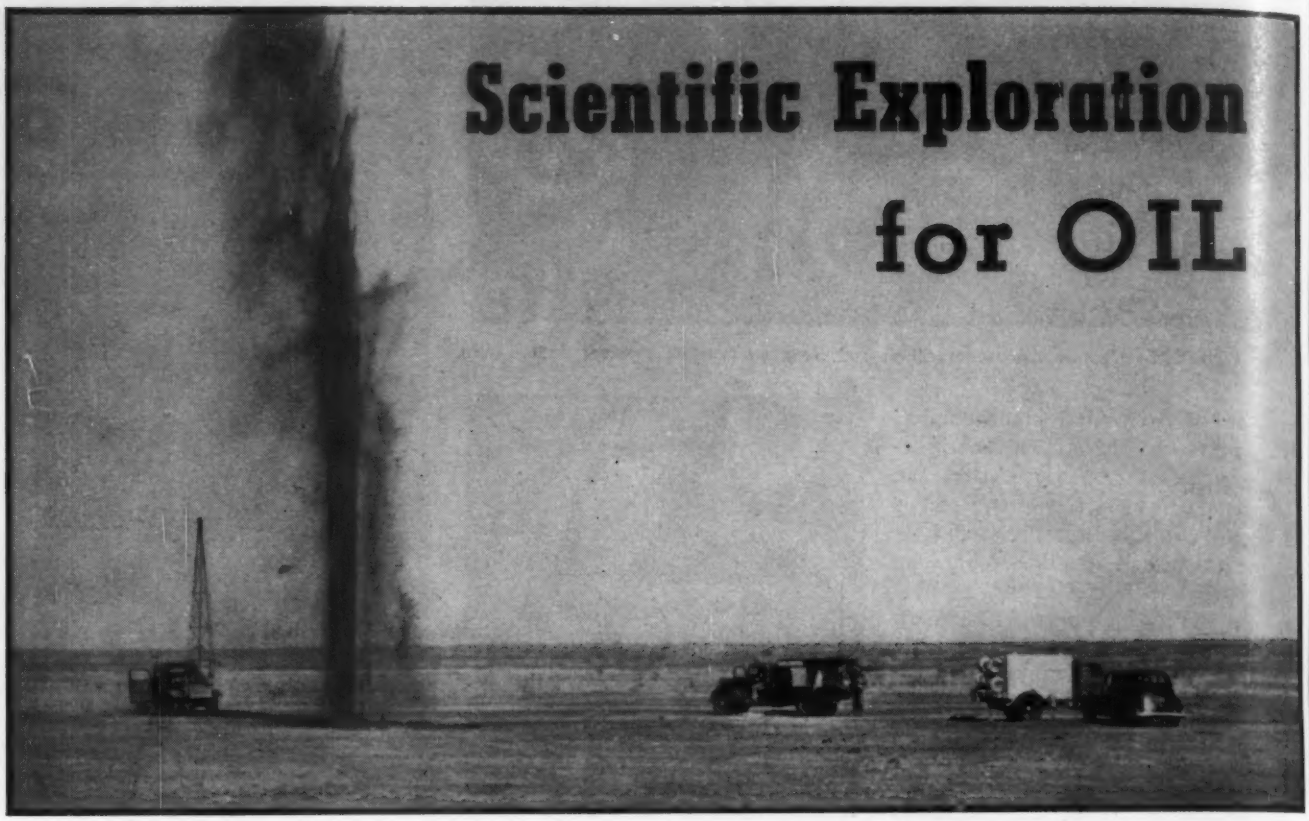
GEOPHYSICS . . .



SHOT—Reflection seismograph setup; rig for drilling 50 to 100-foot holes; shooting-truck for controlling and transmitting instant of explosion; recording truck. This shot was taken a few seconds after the explosion of the dynamite

THE geophysicist has had to draw freely from the electronic art in developing the various prospecting methods used in the search for the subsurface geological anomalies with which oil and gas deposits are often associated. Beginning with the use of electronics in refraction seismograph amplifiers for increasing the effect of the feeble seismic impulse resulting from the distant dynamite explosion and in radio equipment for transmitting and recording the instant of this explosion, the geophysicist has come to accept the vacuum tube as a standard part of his equipment. The successful application of electronics in field instruments has overcome the natural distrust of things that are new and untried. At the present time, electronics is applied successfully to instruments used in all the geophysical exploration methods, such as seismic, thermal, magnetic, electrical and gravitational. For more detailed discussion of the methods than can be given here, the reader is referred to the *Journal of Geophysics* and to the excellent texts referred to in the bibliography.

How Electronics Aids Geophysicists

Modern gravity meters capable of measuring the earth's gravitational field to within one part in ten million employ electronic equipment in both the temperature-control apparatus and the gravity-sensitive and indicating elements. Instruments of this type can be operated both on land and in moderately deep water.

Electrical measurements made at the surface of the earth for investigating the various electrical properties of the upper strata often call for electronic equipment for increasing the sensitivity of the measuring instruments. These instruments are used in making measurements of the natural earth potential, polarization effects, radio field strength, and others. Use is made of direct, alternating, and transient currents for these investigations. An advantage of alternating and transient currents is that quite small potentials can be readily detected and measured by means of high-gain electronic amplifiers and rugged indicating instruments.

The application of electronic equipment in the magnetic method makes possible the construction of sturdy magnetometers of the inductor type for determining the variation in the strength of the earth's magnetic field. Magnetometers of this type can be operated both on land and under water and thus magnetic surveys over varying terrain can be readily accomplished.

When remote control is applied to geophysical instruments, it can be seen at once that some form of electronics can be applied to any present-day method. However, since electronic equipment made its appearance in the geophysical field through the seismic method of exploration and since it remains a very impor-

By DERRY H. GARDNER
Geophysical Research Department
Humble Oil and Refining Co.

In the search for oil and gas-bearing ore, electronics plays an important part not only in aiding in the location of the hunted material but in getting it out of the ground and refining it. Tubes are especially important in connection with the reflection seismograph method of exploration

tant part of today's seismic apparatus, extended discussion will be confined to the role being played by electronic equipment in the reflection seismograph method of oil exploration.

Application to Reflection Methods

For the past ten years, the reflection seismograph method of geophysical exploration has proved to be outstanding in locating petroleum-bearing structures. By means of seismic pick-ups, high-gain amplifiers, and photographically recording galvanometers of the multi-element type, the seismic effects produced by controlled dynamite explosions are recorded and analyzed. The underlying mode of operation of the reflection seismograph is quite similar to that of the sonic depth finder except that in the reflection seismograph method many channels having separate seismic pick-ups, electronic amplifiers and recording units are used. As in the case of the sonic depth finder, the depths to the reflecting strata are determined from the velocities of propagation and the total time required for the seismic vibrations to travel from the point of the explosion to the reflecting interfaces and back to the seismic detectors located at the surface of the earth. The point of explosion, referred to as the shot point, is commonly located from 50 to 100 feet below the earth's surface.

When the seismic waves arrive at the earth's surface, their acoustic energy is converted to electrical energy by means of seismic pick-ups. This energy is then passed to high-gain amplifiers, automatically adjusted to a given level, and the undesired components filtered out, and then passed to recording galvanometers where the photographically recorded seismogram is made. Timing marks at intervals of 0.01 seconds and the instant of explosion of the dynamite charge are recorded on this seismogram, together with the seismic refracted and reflected waves.

When such a seismogram is made with a large number of seismic pickups placed on the surface of the earth in line with the shot point at intervals of around 200 feet, it is possible to differentiate between the direct, the refracted and the reflected waves, because of the difference in their apparent velocity of propagation. The difference in the arrival time at the nearest and farthest pickup from the shot point is usually much greater for the refracted waves than for the reflected waves. Often the reflected waves from the deeper strata arrive almost simultaneously at all seismic pickups on a 1,000-foot spread, whereas the difference in the arrival times of the refracted wave over this spread is

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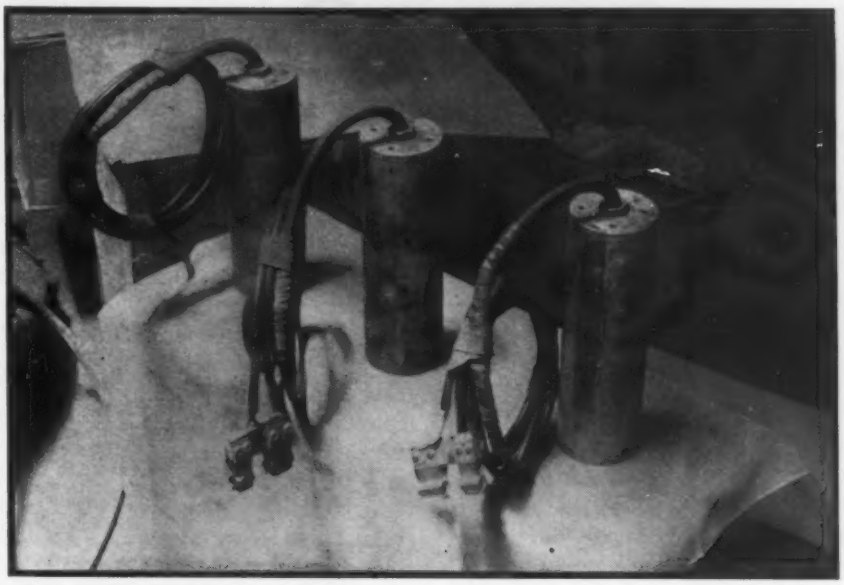
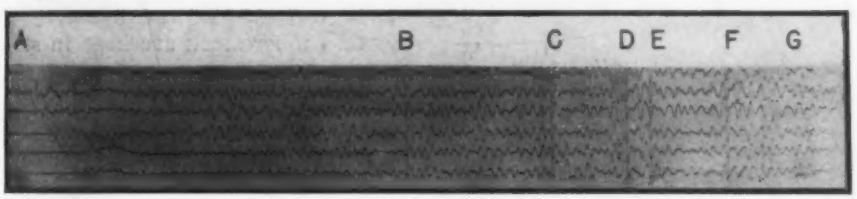


PICKUP—Seismic pickup of the variable-reluctance type. At a frequency of 45 cps and a ground movement amplitude of one millionth inch, this device will deliver approximately one-half millivolt to the grid of the first amplifier, through the appropriate transformer



SEISMOGRAM—Characteristic record obtained by exploding dynamite underground, detecting reflected and refracted waves at points around the "shot hole"

MOTOR CONTROL...

Where speed must be varied within fairly wide limits d-c motors are ideal. Electronic accessories permit such motors to be operated from a-c power lines and at the same time provide a flexibility of control which can be accomplished by no other means

By S. D. FENDLEY

Electronics Sect., Industrial Control Div., General Electric Company

ALTHOUGH the relative simplicity and low cost of the a-c induction motor have made it the most universally used type, it is recognized that for applications where adjustment of speed is desirable, the d-c motor still has no equal. Since industry has largely adopted the use of a-c power, however, it has meant that to use the d-c motor, a special d-c power supply must be provided; this has not always been economical or feasible.

Electron tubes are inherently rectifiers and it was inevitable that they would be used to supply power for d-c motors where such motors were desirable. The rectifier supplied the necessary link between the a-c power supply and the d-c motor.

Its Past

The use of electronic tubes for controlling d-c motors dates back more than a decade. One of the earliest applications was in connection with an automatic lighting control system installed about 1929. In this application, thyratron tubes were used to supply both the field and armature of a small motor to control its speed over a range of approximately 36:1. Following this, numerous electronic speed control equipments were supplied for motors of various sizes and for many different applications.

The principal function of most of the original electronic motor controls was to control the speed of the motor. Other requirements—such as starting and accelerating—were largely provided through the use of various combinations of conventional control devices. There are in service a relatively large number of this type of electronic motor speed controls, and there are still many applications in industry today for their use.

In general, these equipments consist of an adjustable-voltage rectifier using thyratron tubes to supply direct current for the field and armature of the motor. By varying the output voltage of the tubes, the speed of the motor can be changed. Some type of feedback system is employed to do this and it may be of either the mechanical or electrical type.

A typical application employing the use of the mechanical feedback arrangement is that of holding essentially constant tension in the reeling of wire as it comes from the wire drawing machine. By arranging a loop of the wire so that it operates the movable core of a reactor, it is possible to slow down the speed of the reel motor in proportion to the increase in the size of the reel diameter. Essentially constant tension is thus maintained without the use of slip clutches or other similar devices.

The electrical feedback arrangement employs the use of a pilot generator and provides a practical method of holding the speed of one machine at some fixed relation to the speed of another. A typical example may be found in the rubber industry where two conveyors handling a plastic rubber stock are kept in step with each other so that the material will not be distorted in passing from one to the other.

Even though these first motor controls did only the one job of controlling or holding the speed of a motor, they did a job which could not be done so well with conventional apparatus and each installation served to build confidence in the use of tubes for motor service and had a large bearing upon the continued development and use of such equipment.

Its Present

The latest development in electronic motor control is a new control system which provides a means not only for controlling, manually or automatically, the speed of the motor, but also for starting and accelerating it electronically.

This drive consists of an anode

ADVANTAGES OF ELECTRONIC MOTOR CONTROL

1—The rectifier makes it possible to operate d-c motors from a-c power supply.

2—Wide speed ranges are possible without the use of gears, belts, or pulleys.

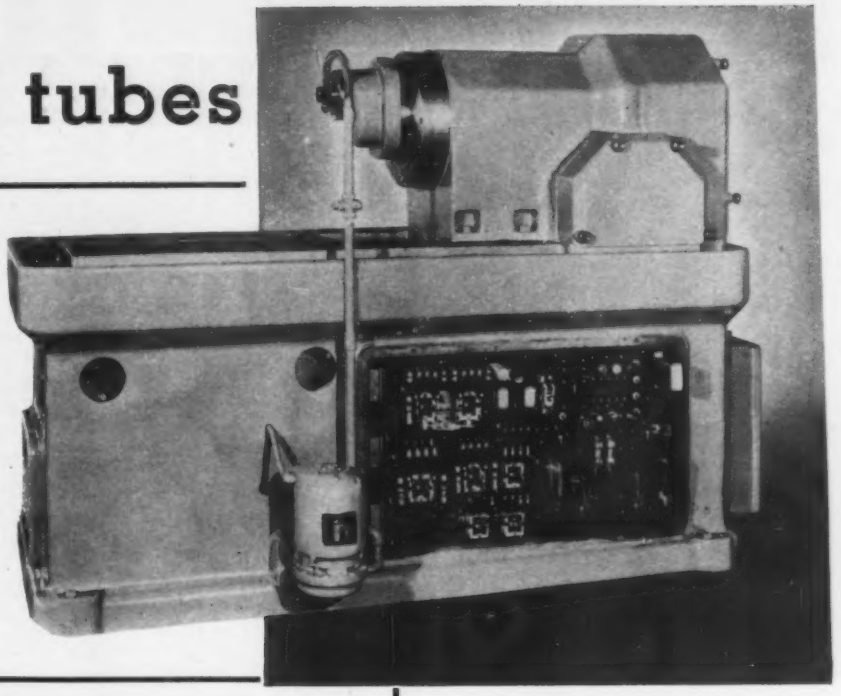
3—Low speed can be provided at full torque and close speed regulation can be maintained even though the load varies from no-load to full-load.

4—The electronic control does not introduce unwanted vibration in a machine, since it has no high-speed rotating or moving parts.

5—Machines equipped with electronic motor control can be moved as readily as when conventional a-c electrical equipment is used.

6—Complete control of the motor, including speed adjustment, is accomplished from a single small push-button station.

...y means of tubes



ransformer, a control and rectifier panel, a control station, and the d-c driving motor. An adjustment in the panel makes it possible to vary the accelerating torque, so that the motor is brought up to operating speed in the quickest time consistent with the nature of the load and the commutating ability of the motor.

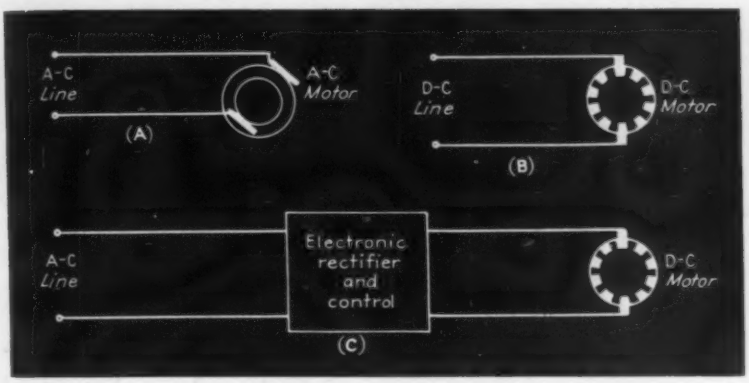
The desired operating speed can be preset and when the start button is pressed, the motor will be smoothly accelerated up to a speed corresponding with the setting of a speed-controlling potentiometer. The motor will always be started with full field regardless of whether the potentiometer is set for operation below base speed by armature voltage control or above base speed in the field weakening range.

A wide speed range is obtainable. The range theoretically may be anything from a value approaching zero up to the maximum for which the motor is designed to operate by field weakening. The practical limits are determined largely by the heating and stability of the motor.

By providing closely regulated armature voltage and automatic compensation for *IR* drop, this system holds the motor speed constant within close limits independent of load and ordinary line-voltage variations.

Because of the outstanding characteristics of this new control system, it has been applied in a number of interesting applications. Most of the drives have thus far been used on machine tools although they have been applied also for such applications as propeller governor testing, automatic welding machines and magneto testing.

Have Your Cake and Eat It Too



Induction motors (A) are conveniently operated from a-c power lines but speed control is difficult to obtain. D-c motors (B) are readily controlled but d-c power lines are not always available. D-c motors may be operated from a-c lines (C) by means of electronic rectifiers which provide control of speed, acceleration, deceleration and even direction of rotation

SPECIAL—Electronic motor control applied to planetary milling machine. The control feeds the cutter into work at a pre-selected speed, automatically switches to another speed for feed-around, rapid-reverses the feed motor at the end of the operation and, finally, shuts off the motor

Among the machine tools to which drives have been successfully applied are grinders, milling machines, lathes and thread millers. Such advantages as increased production, longer tool life, simplification of design and a greater variety of work that can be done, have been reported by users. On a grinder headstock, the wide speed range and constant torque characteristics at low speed make it possible to provide the right speed for every type of grind so that better work can be turned out. On a milling machine, a simple mechanical arrangement for controlling the speed-adjusting potentiometer in combination with a template and follower mechanism has made it possible to maintain constant cutting speed which again has resulted in better work.

Its Future

The electric drive i.e., motor and associated control, probably has been the greatest single factor contributing to the great progress made in the development of modern production machines. The a-c motor and its control will continue to be used

(*Continued on page* 234)

electronic

Medieval alchemists were their modern counterpart is physicists whose
properties were one of the element is to convert one metal

Aid to RESEARCH

MEASUREMENT . . .

basis of all science

By GORDON THOMPSON

Chief Engineer
Electrical Testing Laboratories, Inc.

ELECTRONICS has brought to the everyday measurement of all kinds of physical, electrical and chemical quantities a precision and facility that were thought possible, fifty years ago, only in the national physical laboratories or, with the expenditure of much money and labor, in some special project. Today a factory worker will measure the diameter of a piston or check the frequency of a quartz crystal oscillator with a precision of a few parts in a million as readily as his grandfather measured the width of the new door he was fitting into the old front-door frame. Precision and facility—ease and accuracy—are all brought by electronic tubes.

To describe the thousands of devices and methods for measurements in use today employing electronic tubes would require volumes. As just indicated, every branch of physical, electrical and chemical measurements has been vitalized and carried to hitherto unattainable, to almost incredible, precision and facility. Even to provide a catalog, a mere listing, of applications would exceed by several times the space limits allotted to this review.

Consider first the basic elements of this physical universe, length, mass and time.

Lengths and thicknesses are measured today with pointer-indicating gauges whose scales can be read several feet away to fractions of a ten-thousandth of an inch. (Remember, the "micron" is only four hundred-thousandths of an inch). This precision may be achieved with an electromagnetic structure of which the inductance changes with the position of the measuring spindle, or the spindle may move condenser plates; in either case, electronic tubes amplify the resulting change and deliver the result to an indicating instrument. Even the simple, and basic, machinist's micrometer finds its precision multiplied several fold by using a radio tube to detect contact in place of the sensitive touch of the operator. Various arrangements of "go-and-no-go" gauges with electronic tube indicators permit the gauging of hundreds of parts per hour by one operator as they move past him (or her) down the production line. The electron microscope has made possible the measurement of lengths too short to be amenable to perception by light waves. At the other extreme of length we have the determination of longitudinal distances on the earth's surface (primarily a time determination,) reaching new exactness by the radio, and the estimation of stellar distances extended to new fields because of the electronic tube.

Mass. The measurement of mass has, perhaps, not drawn out the

ELECTRONIC DEVICES AS AIDS TO RESEARCH

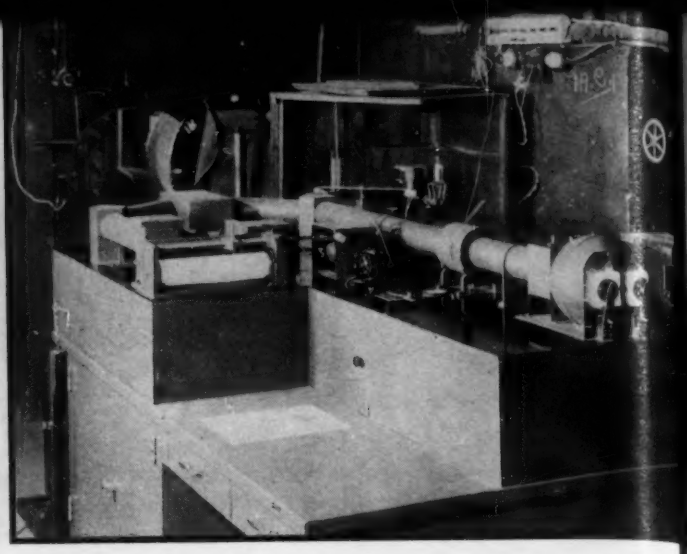
The main function of electronic devices, in aiding research, is to make possible the measurement of *smaller* things than could be measured before with *less disturbance*, by the measuring rod, of the thing measured.

The uncertainty principle teaches that the ultimate limit of smallness that can be observed is reached when the quantity to be measured is smaller than the disturbance caused by the application of the measuring means.

Electronic devices allow us to approach this ideal limit by supplying us with the lightest known measuring agents, electrons and photons.

—A. W. Hull
***Physics*, 2, 409, 1932.**

UHF—Measuring equipment in double-shielded room at the Electrical Testing Laboratories. Left—radio receiver; center foreground—Schering bridge; center at rear—radio frequency signal generator; right—quartz-insulated standard air capacitor



SPECTROPHOTOMETER—This is the celebrated instrument devised by Dr. A. C. Hardy, MIT, for measuring transmission or reflection factors of materials at any and all wavelengths in the visible spectrum. It uses four types of electron tube

great variety of electronic devices that have been created for length and time measurements. But the continuous weighing of loaded conveyors has been greatly improved with the application of amplifiers, and electronic tube accessories for scales and balances have increased sensitivity and eased the tension of the observer's concentration. One such arrangement yields audible signals so that an operator does not need to look at the scale beam to know that it is level. The mass spectrometer gives trajectories to electrons indicative of their masses and is a powerful tool for the separation of isotropes.

Time. In the field of time measurements the electronic tube has probably made its greatest contribution. The variable frequency tuned circuit, sustained by the electronic tube, is a powerful measuring tool. Controlled by the piezo-electric voltage of a quartz bar, such circuits have yielded time values accurate day after day to better than one part in a million, a precision that the finest astronomical clocks could maintain for only relatively short periods. The electron tube and the resultant high-precision time standard not only makes correct time available as a commercial product but furnishes standard concert pitch to orchestras everywhere. The cathode-ray oscillograph records phenomena which may occur "but once in a litetime" and which may transpire in a few millionths of a second. With a variable-frequency sweep circuit such an oscilloscope can hunt out the frequency of an unknown voltage and exhibit the contours of its wave shape.

Measurement of Other Physical Quantities

The measurement of *temperature* and especially the control of temperature finds new facility and precision because of the electronic tube. The familiar basic devices—expanding metals and liquids, thermocouples, resistance thermometers—work now through electronic amplifiers so that indicators and recorders can carry more sensitive scales, or the temperature of a space, of a surface or a kettle of liquid may be maintained with smaller drifting. The measurement of *moisture* and humidity in rooms, chambers, foods, lumber, soil, and so on, is a related field for which ingenious devices and arrangements utilizing electronic tubes are available.

An oscillating tube circuit of which the frequency can be varied at will may excite a flashing light (stroboscope) which illuminates a rotating machine; the frequency of the light which "stops" rotation measures the machine's *speed*. And since the measuring device has no mechanical contact with the rotating object it may measure the speed of the smallest-powered machine without altering the speed under observation. Obviously this rapidly flashing light may be used for high-speed photography which has become a powerful measuring aid in the study of high-speed operations. Of course, when the frequency is held slightly off synchronism the motion of even a high-speed mechanism may be studied closely. Unbalanced vibrations in high-speed machines, down to hundred-thousandths of an inch, may be measured and corrected. Or with various types of pick-up mechanisms, coils, condensers, microphones and the like, the nature of the vibration may be analyzed and the guilty source detected. The accelerometer used to determine effective *weight* during the evolutions of an aeroplane trial flight, for example, is available solely because of the development of electronic tubes.

The *sound* level meter and associated analyzing equipment which utilize electronic tubes may perform a service similar to that of the "vibrometer" through the medium of the noise emitted by a rotating or vibrating mechanism, or may evaluate the effectiveness of devices and materials placed to minimize the noise penetrating to spaces which should be quiet.

The measurement of the *power* transmitted by a shaft has always been an alluring subject to the physicist; when the shaft itself can be calibrated as a torque-meter, electronic devices can step up and furnish a power scale. Electric resistance strain gauges now take their place beside electromagnetic and

INSTRUMENTS—Typical commercially available devices in use at ETL. Sound level meter, stroboscopic tachometer, cathode-ray oscilloscope, vacuum tube voltmeter, amplifier for power frequencies, susceptance-variation circuit, bridge and wavemeters

PHOTOMETRY—Sphere in which light is evaluated by a phototube which "sees" like the human eye by means of accurately adjusted chromatic filters. Phototubes give greater accuracy than the human eye; they do not suffer from fatigue

mechanical strain gauges for measuring shaft distortion as well as the more familiar function of measuring distortion under static stress, and for all of them the electronic tube amplifier is a willing and able servant. Engine indicators now make use of the piezo-electric effect of crystals and with suitable electronic tube amplifiers deliver linear responses without the use of elaborate linkages. Study of engine performance are readily made.

Measurement of Electrical Quantities

Electric *voltages* can be measured with electronic tubes with precision up to frequencies of the order of millions per second and with the withdrawal of negligible power from the circuit measured. The vacuum-tube voltmeter may measure the peak voltage of a fluorescent lamp or of a proof-voltage testing circuit or of the surge from the starting of an oil-burner mechanism. Chemical reactions may generate voltages with certain electrodes and although the accompanying energy is too minute to be detected by other means, the electronic tube voltmeter or potentiometer serves the purpose. The hydrogen ion concentration (pH) method of determining acidity or alkalinity and the measurement of electrolytic conductivity are of this nature. The measurement of *electric current* in terms of the voltage drop across a known resistance traversed by the current to be measured is a procedure familiar to every electrical technician. With electronic tubes the minuteness of the current which can be measured in this way is so great that negative decimal exponents must be used to avoid the string of ciphers otherwise needed to express the value.

Invariably a method of control can be used as a method of measurement and vice versa. The mercury-vapor "valve" (thyratron) with the phase of its grid voltage altered by the quantity to be controlled has found hundreds of applications. For example, the voltage of a generator may be held constant to one part in a thousand while its load fluctuates over a wide range, because such a tube or group of tubes acts instantly to readjust the exciter field current to the new value required by the load. Motor speed may be controlled.

Wheatstone's "bridge" network for the comparison of electric resistances was the basis for the *alternating-current bridges* proposed by Wien, Maxwell, Anderson and others years ago. The a-c bridges and other balanced circuits now used to measure resistance, inductance, capacitance, power factor, loss angle and so on, over the whole frequency spectrum, are numbered by the hundreds. For practically all of these electronic detectors and amplifiers are used. At frequencies of the order of megacycles, a good radio-broadcast receiver using perhaps 10 or more electronic tubes replaces Wheatstone's simple coil and magnetic needle type of galvanometer.

Measurement of Illumination

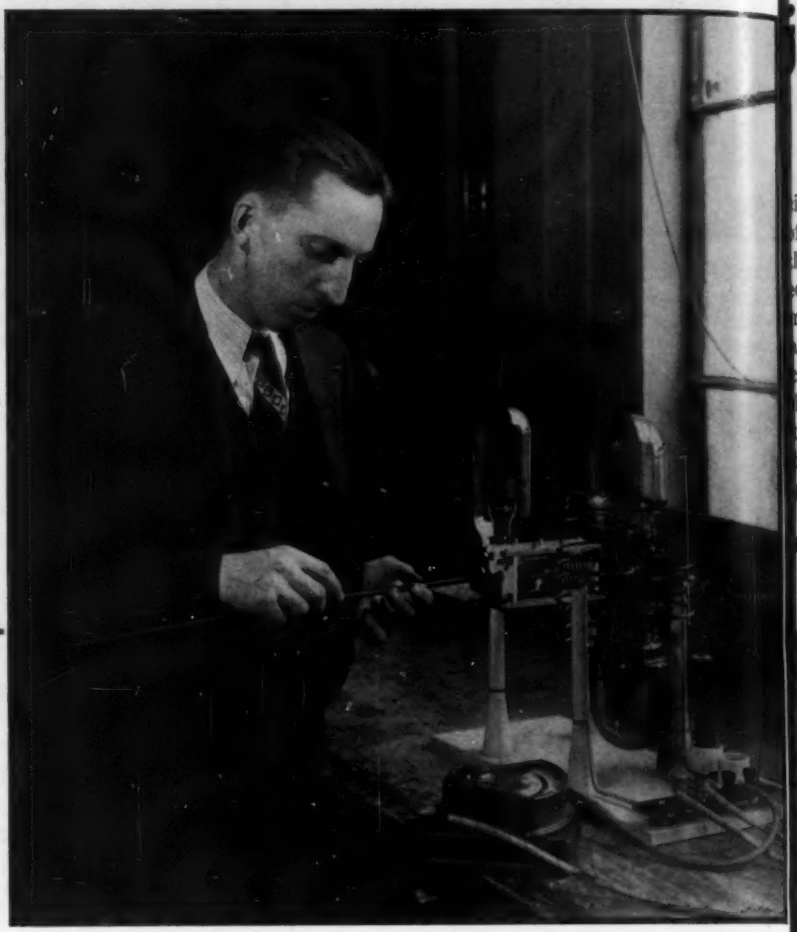
The photo tube and the photoelectric barrier-layer cell are close cousins to the electronic tube. And the electronic tube amplifier is ready with a linear magnifier for their feeble currents to aid in measurements of *light and illumination*; here again there is a notable gain in precision as compared with the ocular method of comparison involving brightness equalization and color-matching. In some instruments a variety of electronic tubes are combined to produce a measuring device; for example, the Hardy spectrophotometer utilizes a caesium phototube, a rectifier tube, several amplifier tubes and grid-controlled mercury-vapor tubes for recording automatically the result of a photometric measurement with monochromatic light at wavelengths throughout the visible spectrum. A similar tool is the microphotometer for evaluating spectrograms and distribution patterns of radiant energy.

In step with present-day life, measurements have become so complicated an activity that a specialist must usually be called in to make repairs and adjustments when the measuring tool "goes wrong." Nevertheless, the facility and accuracy made available by the application of electronic devices have been so positive and so economical that continuously expanding development and use are confidently expected. Thus electronics aids research.

MEDICAL

Several electronic tools are now available to the practicing and the research physician — x-rays, the electrocardiograph, high-frequency therapy, the "electric knife". The physiologist and the biologist as well are learning how to use electron tubes

By W. E. GILSON, M.D.
Department of Physiology
University of Wisconsin



THERAPY—New high frequency tube (WL-461) which will permit doctors to obtain higher power at higher frequencies for high-frequency therapy

CONTRIBUTIONS OF ELECTRONICS TO MEDICINE

1856—Discovery of potentials produced on surface of heart during contraction.

1875—Caton showed presence of brain potentials.

1887—Waller demonstrated that cardiac potentials could be obtained from two parts of the body with the heart between them.

1890—d'Arsonval experiments on biological effects of high frequency currents.

1895—Roentgen discovered x-rays.

1898—X-rays applied to biological sciences.

1903—Einthoven described string galvanometer.

1913—Einthoven electrocardiographic apparatus widely used in U. S. A.

1913—Coolidge produced the hot-cathode x-ray tube.

1924—Hans Berger recorded and analyzed brain potentials.

1925—Beginning of use of vacuum tube oscillators for high frequency therapy.

1928—Beginning of use of electronic amplification for clinical electrocardiography.

1828–1943—Multitudinous applications of principles enumerated above.

AS in other fields, the last decade has seen a remarkably increased use of electronics in both clinical medicine and fundamental research. In general, the electronic device is developed for research and later given a wider application in medical practice.

As would be expected, electronics is applied far more generally in research, because of the number of special problems which are encountered and because of the relative complexity of some of the devices used. It usually requires several years before an electronic device has been simplified sufficiently so that it can be put in the hands of a physi-

SCIENCE

joins hands with electronics

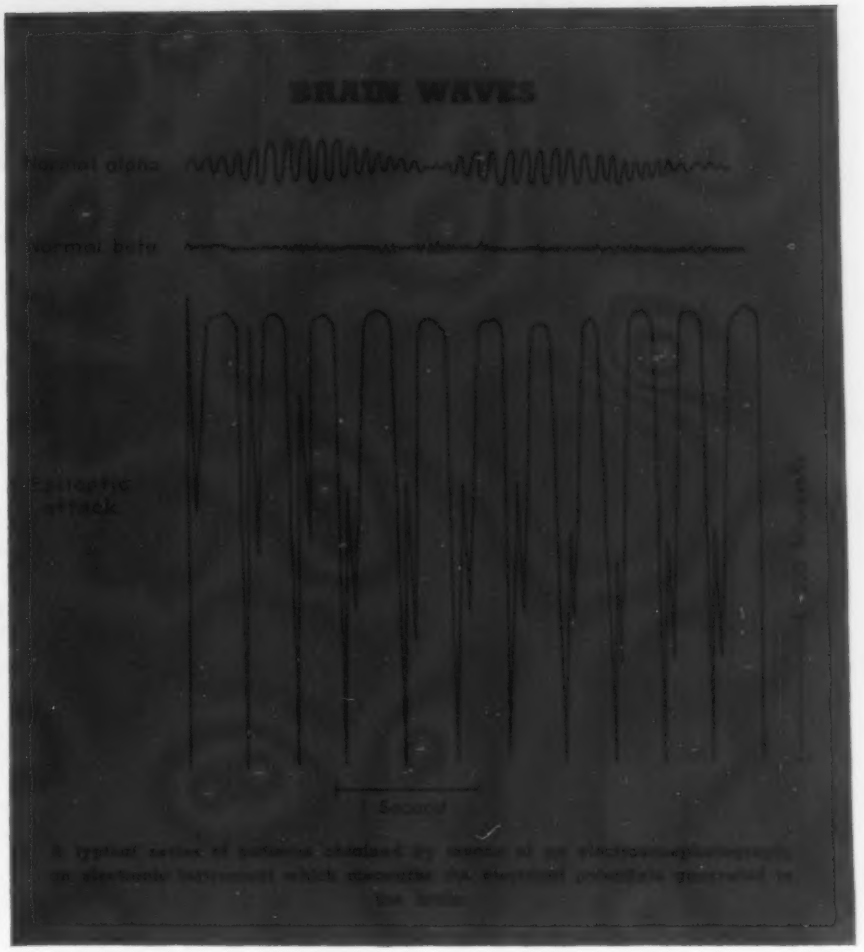
ian who is not trained in the use f vacuum tube circuits. Each of he large companies making such quipment has a number of service- nen trained to make repairs when breakdown occurs. Most of them arry a pair of pliers and a screw- river and the necessary knowledge o enable them to locate and remedy he trouble. Others carry a pair of liers and a screwdriver.

X-rays Were First Electronic Application in Medicine

The Roentgen ray machine was he first electronic device to be used n practical medicine. As is well known, the penetrating power of the rays was first observed by Roentgen n 1895 while experimenting with a Crookes tube. He realized the value of his discovery, and both clinical and technical development proceeded rapidly.

The first tubes used clinically were gas filled, with a cold cathode. Following his development of a method of producing ductile tungsten, W. D. Coolidge in 1913 produced the first hot-cathode tube. Such tubes are almost universally used at present, the high voltage applied to their plates being full-wave rectified a.c. The anode of the tube is strongly positive with respect to the cathode and attracts electrons to it with a high velocity. These electrons strike its tungsten surface and produce a molecular agitation which results in the formation of x-rays. In the Coolidge tube the strength of the rays can be controlled by varying the cathode temperature, and the hardness of the rays can be varied by changing the anode voltage. With higher voltages the penetrating power is greatly increased.

The lower-power x-ray tubes are air cooled, the larger tubes are cooled by circulating water, and the newest method of cooling uses a rotating anode so that the heat is spread over a larger surface. The anode is connected to the rotor of an induction motor which is contained within the glass envelope of the tube. The field coils are just outside the tube, separated from the armature by a thin layer of glass.



The x-rays have the power of exciting to fluorescence such substances as calcium phosphate, barium platino-cyanide, and zinc sulphide. If one of these salts is applied in a thin layer to a cardboard support, it provides an excellent means of observing the effect of the rays and the shadows produced by interposing any object to be examined between the screen and the x-ray tube. It is used clinically in this manner, as in the familiar fluoroscope.

X-rays also have an effect on photographic film similar to that of light, in that the silver halide particles are made susceptible to the action of developers. Pictures can thus be made of the x-ray shadows. In modern practice the film is sandwiched between two fluorescent screens, called the intensifying screens, to increase the sensitivity of the combination. The light pro-

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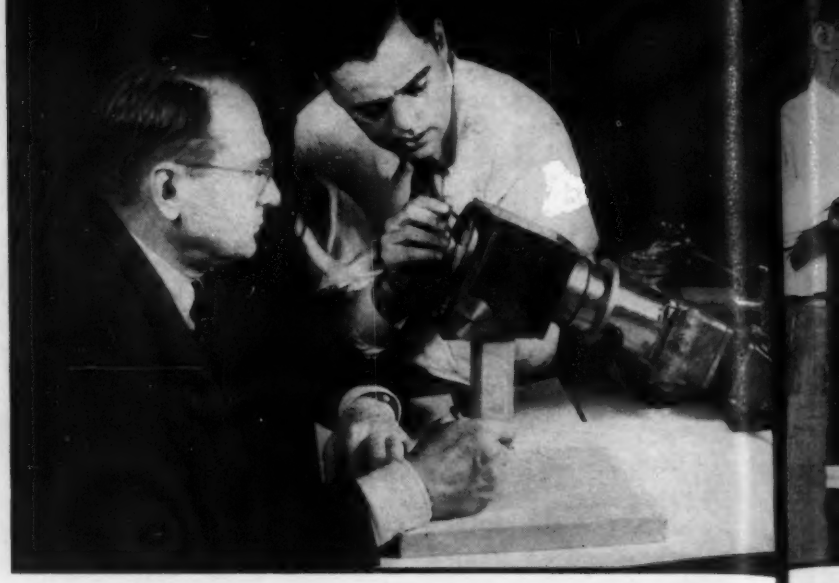
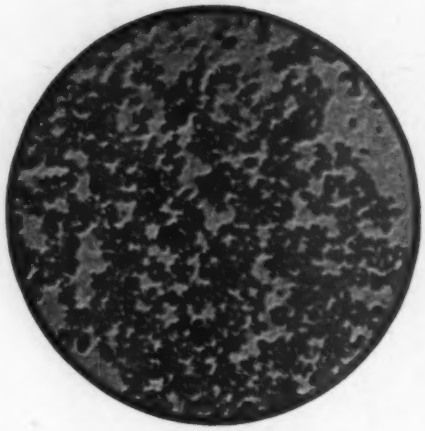


PORTABLE—Small, inexpensive microscope developed in RCA Laboratories. Drs. V. K. Zworykin and James Hillyer are inspecting the new 16-inch instrument, a distinct contribution to research.

POLYSTYRENE
Magnified 70,000 times



MERCUROCHROME
Magnified 65,000 times

ELECTRON M

Most Recent R

By **V. K. ZWORYKIN**, *Associate Director, RCA Labs*

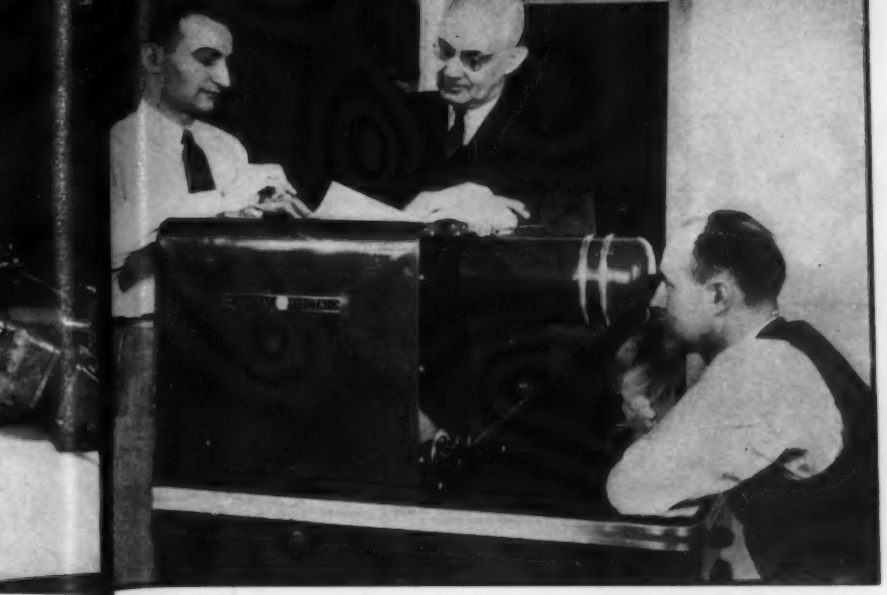
FOR MANY YEARS one of the most useful and practically indispensable tools at the disposal of metallurgists, chemists, physicists and biologists (including bacteriologists, pathologists, botanists, entomologists and the family doctor) has been the light microscope. Yet, in spite of the extension of vision that it provides for the innumerable workers in these sciences, the light microscope has well known limitations which prevent it from answering many of the problems which continually arise. It is to remove these limitations and to give the workers a still greater extension of vision that the electron microscope has been developed.

The electron microscope exists as a result of the discovery that an electron, or any electrically charged particle of matter, traveling through electric and magnetic fields obeys the same mathematical laws as a beam of light traveling through various optical media. This discovery led directly to the possibility of construcing lenses for electrons employing electric and magnetic fields through which the electrons are made to travel. Immediately there arose the possibility of duplicating in electron optics all the types of apparatus which use the lens systems of light optics. Scientific curiosity would probably have been, in itself, sufficient stimulus for the development of the electron microscope. However, a much more potent one was soon at work. For, it was realized that the limitations of the electron microscope were similar in nature to those encountered in the light microscope but about 100,000 times smaller! In other words, a perfected electron microscope should be capable of producing useful magnifications of the order of 200,000,000 diameters instead of the modest 2,000 diameters attainable with the best optical instrument.

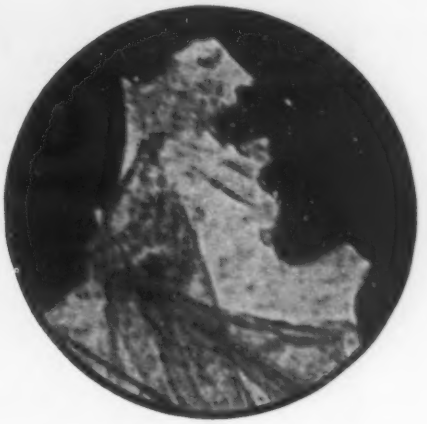
Of course, it is not expected and not even essential that such a fantastic increase in resolving power should be achieved in the near fu ture; in fact, there are reasons fo believing that all of it will never b achieved. From the practical micro scopist's point-of-view, however, re solving powers which are 10 t 1000 times better than that of th light microscope are of greate value; beyond that the indirec methods of atomic physics are muc more useful. Already, the electro microscope has been developed t the point where the resolving powe is about 100 times better than th light microscope.

The electron microscope itself i nothing more than the electron optical counterpart of the light mi croscope. The well-known lenses o the light microscope have been re placed by magnetic or electrostati lenses; an electron source has re placed the light source; the re mainder of the structure is merel designed around the fact that all th elements of the system must be i a vacuum chamber.

During the past two years a sub stantial number of electron micro scopes have been put into operatio in various industrial, medical an university laboratories in this coun try and, in spite of the fact that th time of working with these instru ments has been short, many start



LABORATORY — G-E microscope which uses electrostatic lenses. Like the new RCA instrument, it will serve to bring the electron microscope to many hundreds of laboratories. Dr. S. Ramo, W. C. White and Dr. C. H. Bachman.



FACE POWDER
Magnified 54,000 times

ON MICROSCOPE

ent Research Tool

RCA Labs

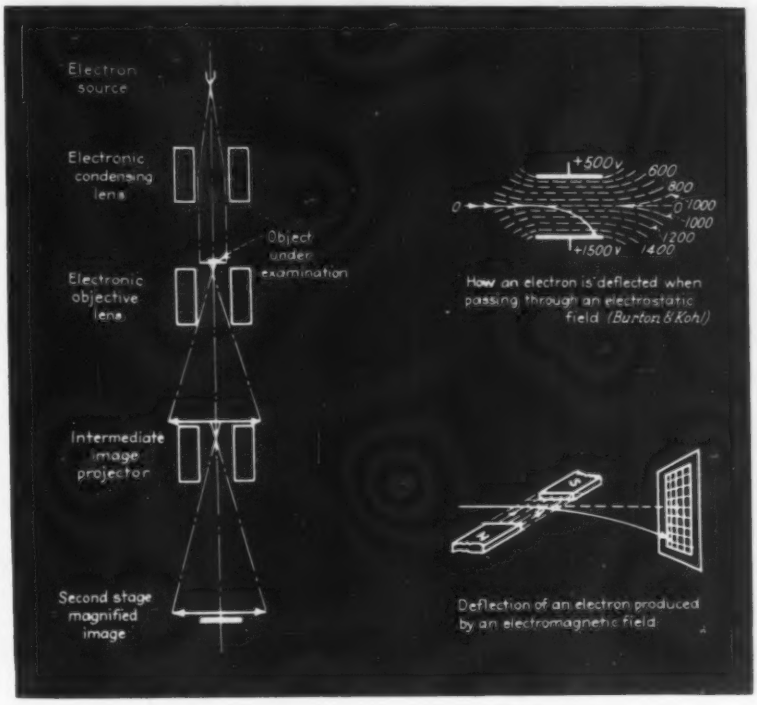
ing discoveries have already been made. A large number of viruses ave been observed for the first ime, confirming predictions based n indirect methods of investigation. Of these smallest forms of life, ome have been found to have rather omplicated structures in spite of heir extremely minute dimensions. Much exploratory work has been one in the fields of bacteriology and mmunology. Thus, specific actions f anti-serums as well as many tructural problems with bacteria ave been investigated. Most of this work has been done in an effort to explore the possible fields of applica- ion of the electron microscope and as not as yet settled down into the routine investigation of specific problems.

The electron microscope has al- ready proven its value in industrial hemistry. Many of the problems ncountered involve the shape and ize of chemical particles. Here the lectron microscope can be used to est advantage, for the results are iven directly, quickly, and without ny possibility of doubt. Even in his field of application the surface as scarcely been more than cratched.

The fact that the electron micro- cope is capable of much greater esolving power than the light micro-

(*Continued on page* 254)

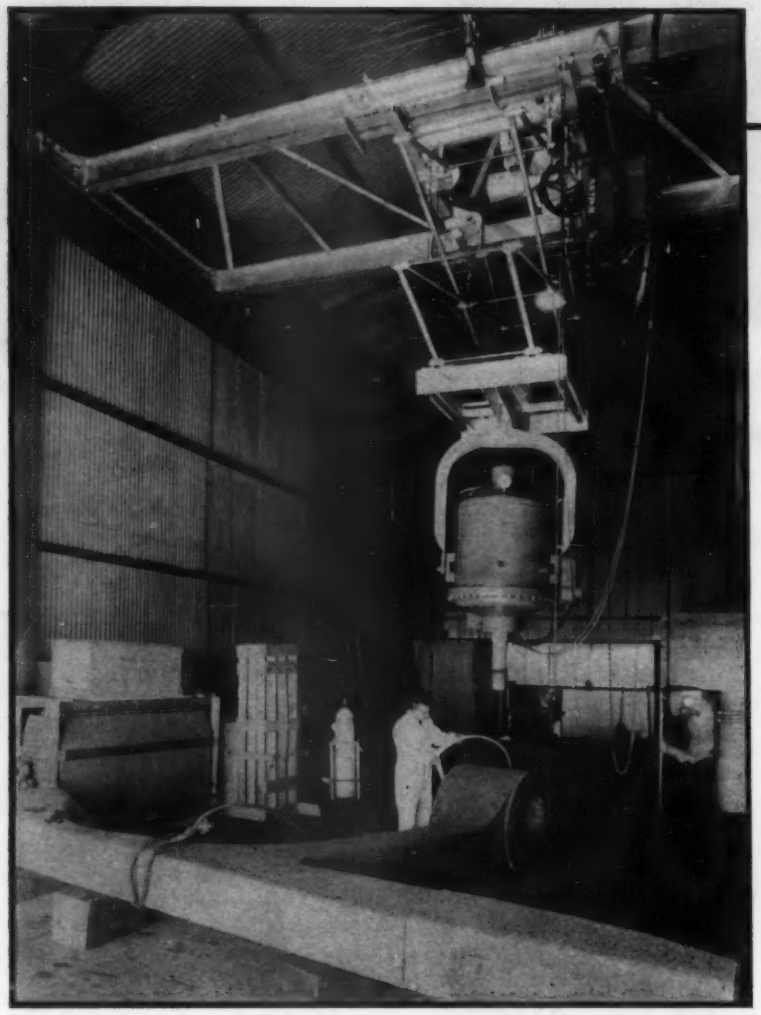
Basic Electron Microscope Principle



A fundamental discovery led to the development of the electron microscope. An electron in motion may be deflected by an electrostatic or electromagnetic field, much as light rays may be deflected by glass lenses. Thus a group of electrons speeding along a path can be concentrated or caused to diverge. In the electron microscope a heated cathode provides the electrons and these electrons take on the characteristics of the object to be examined when passing through it. They are then spread apart to produce an enlarged electron image of the material on a photographic plate or fluorescent screen.

X-RAYS...

First E



INDUSTRIAL GIANT—1,000,000 volt x-ray unit in position for examination of large casting. Entrapped slag, cracks, porosity and incomplete fusion are shown by this machine, which will produce a record on film through a 6-inch thickness of cold-rolled steel in 15 minutes

THE function of electronic devices as aids to research is largely to make possible measurements which could not previously be made. The extension of physical measurements through the use of electronic devices results from the extremely minute size of the elementary particles (electrons or photons, wavelengths of x-radiations, and the like) employed in electronic instruments.

X-ray diffraction methods have been widely adapted to the study of crystal structure since the wavelength of x-radiations is of the same order as the spacing of crystal planes which may be considered to lie between 1 and 20 Å. The wavelength, in Angstrom units, of radiation produced by an x-ray tube is so related to the voltage, V, that an x-ray tube operating at 30 kilovolts produces waves of 0.4 Å, which is of the same order as the interplanar crystal distances and thus suitable for such measurements. ($1\text{Å} = 10^{-10}$ meter.)

If a heterogeneous, parallel beam of x-rays is directed against a single crystal, the regular lattice structure of the crystal will diffract the x-rays in such a manner as to produce on a photographic plate a regular pattern or symmetrical design which is characteristic of the crystal under observation. Through the use of a monochromatic beam falling on the crystal, and various arrangements of crystal mountings and positions, line spectra or other diffraction patterns are obtained, which, upon analysis, may be made to yield considerable information as to the true nature of the crystal structure.

It is not the purpose of this article to discuss the various technical arrangements which may be used, nor the equipment required for such diffraction analyses; we shall be concerned with the applications of x-ray diffraction methods, however.

The application of x-ray diffraction to the problems of research in crystallography and to problems of applied science in chemical analysis and metallurgy, would fill many pages of ELECTRONICS, even in a condensed list. The scope of the information obtained with this method includes the nature of the crystallographic system, uniqueness or aggregation of crystals, grain size, internal distortion or strain, and the state of atomic chemical combination in a substance.

Applications to Metallurgy

In metallurgy, x-ray analysis is applied to the study of the constitution of alloys, their intermediate phases, solid phases, and crystalline structure. The effects of cold-working in producing grain distortion, fragmentation of crystal grains, and the introduction of preferred orientation by rolling and drawing are readily determinable, and methods for improving processes can be definitely established. Concerning the practical applications of x-ray diffraction to problems of the metallurgical industry, G. L. Clark writes in his book "Applied X-rays" (McGraw-Hill Book Co., 1940): "Without undue enthusiasm it may be stated

By MORTON D. FAGEN
Massachusetts Institute of Technology
(on leave from G-E X-Ray Corp.)

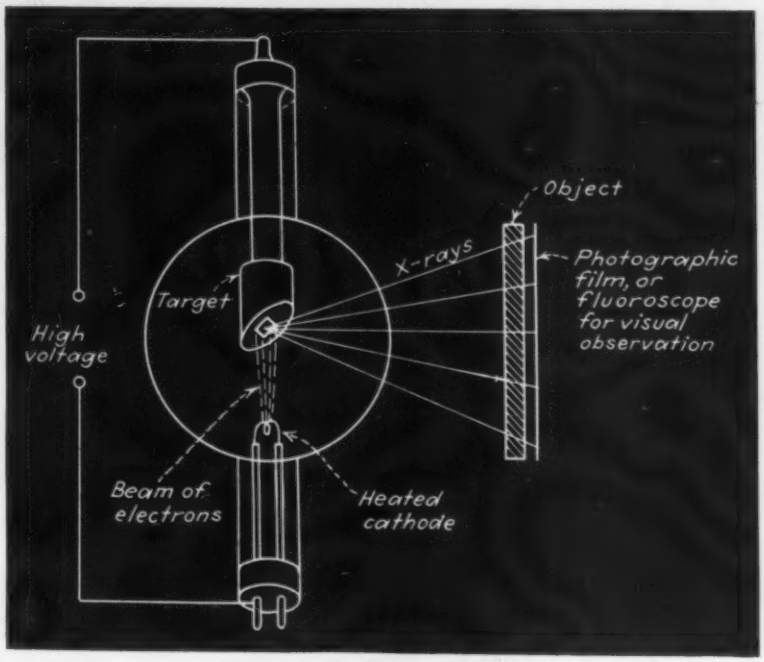
Electron-Tube Application

In wartime production, x-ray examination methods are of extreme importance. Gun mounts, cylinder blocks, crankshafts, armor plate, airplane propellers, valves, boilers—all offer good targets for x-radiation. Some lesser known uses of x-rays in research are described

as a fact that the contributions of x-ray research to metallurgical science *over so few years* surpasses the record of all other experimental methods."

Crystallography

The determination of a particle size has been extended into the range of submicroscopic grains, as in crystalline colloids of 10^{-4} to 10^{-6} cm. Substances like rubber, carbon-black, paint pigments, cellulose, glasses and other substances usually considered amorphous have been found to give diffraction rings, and even some liquids produce diffraction haloes which yield important information as to their nature and structure. Soils, minerals, dusts, and clays are being analyzed with new techniques, and the study of fibers as found in drawn metal wires, silk, muscle tendon, fibrin of blood, cotton, wood, rayon, starches, and stretched rubber is opening new approaches to geology, biology, and industrial medicine. Another and similarly new phase of crystal analysis is the investigation of the crystalline and molecular structure of organic compounds, leading to new insight into the mechanism of lubricating films and the behavior of insulating oils and waxes. Research on synthetic resins and synthetic rubber is dependent on diffraction patterns as an aid to the study of polymers with giant molecules.

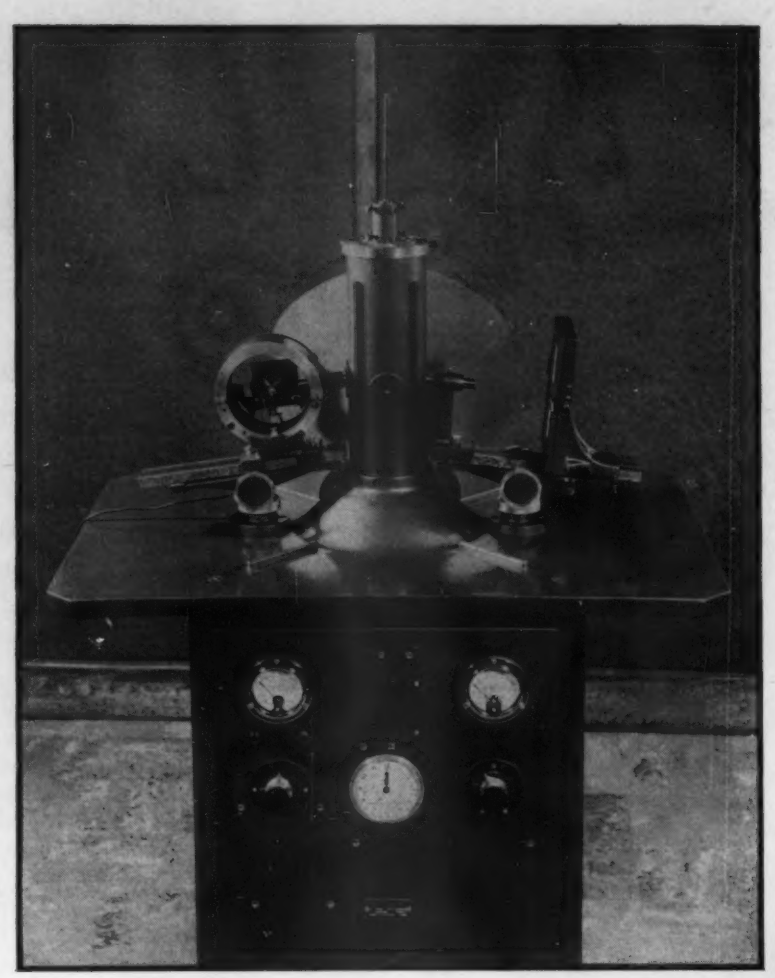


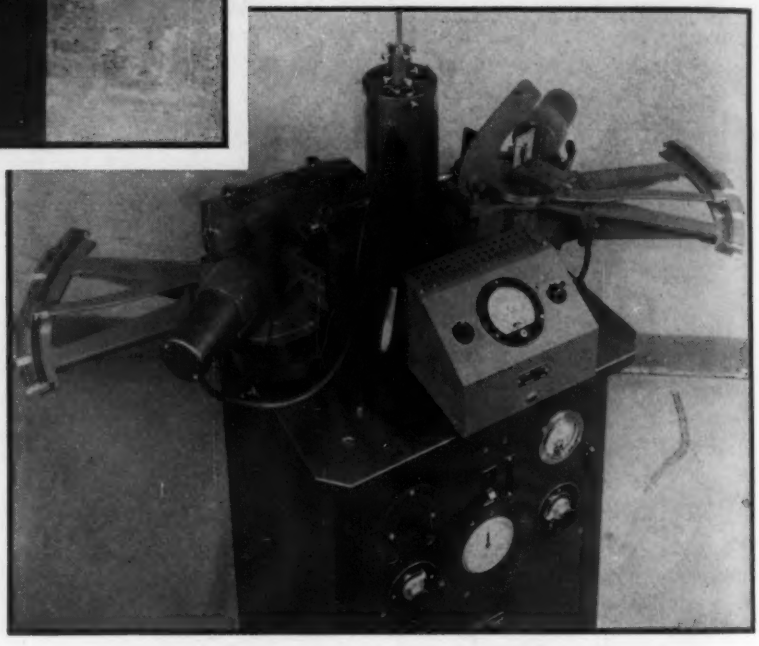
How X-Rays Work

High speed electrons strike target and deliver kinetic energy. Rays of light of extremely short wavelength, x-rays, are produced. These rays pass through materials to be studied to a greater extent than do rays of visible light; therefore objects of greater density (steel or concrete) can be penetrated by x-rays to expose photographic plates or be visually observed on fluorescent screens

Chemical Analysis

In the field of analytical chemistry, x-ray diffraction is rapidly growing in importance as systematization of patterns for reference is proceeding. The diffracted x-ray beam differentiates between a mixture, which produces superimposed patterns; a compound, which gives a pattern different from the constituents; and a solid solution, which resembles one or the other of the constituents with slight alterations. "Finger-print" files of more than a thousand chemical substances have been brought together to aid in the rapid identification of diffraction patterns obtained from as little as 0.2 mg of the unknown substance in powder form. Since only about 5 percent of the solid inorganic substances are essentially amorphous the field of application is quite inclusive for qualitative or semi-quantitative analysis. Operationally, the x-ray method of chemical analysis is particularly useful in that the preparation is simple, the analysis requires minute quantities of material, and different states of oxidation, hydration, or crystalline phase are dis-





DIFFRACTION—(Above) G-E diffraction study x-ray unit, with two of possible four cameras in place. The one at the left is a powder camera for Hull-Debye-Scherrer patterns. At the right is a collimator assembly and flat cassette for Laue patterns. (Right) Diffraction x-ray equipment designed specifically for determining crystallographic axes of quartz. Intensity of x-rays after diffraction by crystal is measured by ionization chamber and amplifier system

about surface layers with regard to crystal formation, orientation and grain size.

Electron Diffraction

Electron diffraction work on polished metals has given valuable information on the causes of piston and bearing wear. Research on the general problem of adhesion of electro-deposited metals can be expected to result in substantial improvements in plating techniques, while the knowledge gained of surface chemistry, of corrosion, and of the protective oxides on metals and alloys, is directly effective in solving many problems, theoretical as well as intensely practical.

The method is new and relatively little used. Improvements in techniques will overcome some of the present limitations, will make possible the use of any type of surface, and will permit electron focussing for limiting the area to any desired spot. Special tubes have been built for high temperature researches, and it is reasonably certain that the mechanical inconveniences of present systems will be overcome with further work.

tinguishable on the pattern. At the present state of the art the quantitative accuracy of results in favorable cases is 5 percent but there is ample reason to believe that future developments will greatly increase the precision.

Just as waves from x-radiations may be scattered and diffracted, so may a beam of electrons be similarly scattered by the atoms of a crystal acting as a three-dimensional diffraction grating. This result, experimentally demonstrated by Davisson and Germer in 1927, verified the theoretical prediction of DeBroglie, three years earlier, that a particle in motion would have waves associated with it. As a result, electron diffraction methods have been devised which provide a practical means for obtaining structural information

X-ray Absorption

X-rays are absorbed to a certain extent by all substances through which they pass. The portion of the

x-rays which are absorbed depends upon the thickness of the absorbing medium through which the rays travel, the character or nature of the absorbing medium, and the wavelength of the x-radiation.

As an aid to research, the method of x-ray absorption has become possible as a result of a history of the earlier investigations which were, in themselves, intended to explain that very phenomenon. For example, research on the effects of direct radiation on living tissue has led to new concepts in biology and genetics, and to the utilization of x-rays as a tool for research in these fields. In similar fashion, experimentation with x-rays on hundreds of chemical substances in the effort to find reactions which might be used as quantitative means for radiation measurements has prepared the background for the use of x-rays in the study of mechanisms and the rate of chemical reactions and the stability of chemical bonds.

Absorption methods may be used to determine the true thickness of various specimens of material whose absorption coefficient is known, to determine porosity (as in welds or castings) of the aborbing material, to differentiate between genuine and counterfeit coins, precious stones, or other articles which may appear similar but which have different absorptions for x-rays, to determine variations in thickness of sample materials, to detect gross flaws such as cracks or fissures, or for determining the composition of mixtures and solutions.

Photochemical and Biological Reactions

Molecules of water and some very dilute solutions are activated by x-radiation, becoming unstable and highly chemically reactive. Hydrogen peroxide is formed from water with dissolved oxygen present; dilute solutions of organic compounds are decomposed and hydrogen, carbon dioxide and oxygen liberated. Oxidation and reduction processes occur with radiation as, for example, the oxidation of Fe SO_4 and the reduction of KNO_3. Catalysts are activated in the presence of moisture and metastable solid states of some substances are converted to stable forms. Cell proteins are denatured and flocculated, a reaction which is of great importance in the biological effects of x-radiation.

The production of changes in the composition of genes and the establishment of mutations of form, size, color and reproductive power has led to the use of x-ray and gamma ray absorption as the only means of artifically producing these changes. The treatment of cancer by destruction of localized growths is an extremely important therapeutic technique for the control of advanced malignant disease, and for the cure of a great number of less advanced cases. Medical research on the biological effects of radiation and the nature of cancer is bringing us closer to the reasons for much of what is now known empirically. This research is largely dependent on electronic devices for producing x-rays, now commercially available in various units, to cover the entire spectrum of wavelengths from 1 Å (10 kv) to 0.01 A (1000 kv).

PATTERN — Laue pattern of cold-drawn steel, obtained by means of x-ray diffraction equipment. Sharply defined rings are evidence of fibering and fragmentation which greatly affect mechanical properties of material

The newest source of penetrating radiation and high speed electrons is the magnetic induction accelerator.* By using a magnetic field to produce a spiral electron path and by causing the electrons to be continually accelerated by a time variation of the field, a velocity equivalent to that obtained with 5,000,000 volts can be obtained in a tube only 20 cm in diameter. The distance traveled by an electron from the injector to the target has been calculated to be about sixty miles and the radiation is equivalent to that obtained from one gram of radium. A large induction accelerator has recently been completed which produces electrons with energies of 100 million electron volts. What this will mean to nuclear investigations and biological research is just becoming evident. Only the future will reveal the ramifications of the present beginnings.

* Krest, D. W., *Physical Review*, 60, 47–53, 1941.

BIBLIOGRAPHY

Buerger, M. J., "X-ray Crystallography," John Wiley and Sons, N. Y., 1942.

Chalmers, Bruce and Quarrell, A. G., "The Physical Examination of Metals," Vol. II, Longmans, Green, N. Y., 1941.

Clark, G. L., "Applied X-rays," McGraw-Hill, N. Y., 1940.

Compton, A. H. and Allison, S. K., "X-rays in Theory and Experiment," D. Van Nostrand, N. Y., 1935.

Davey, W. P., "Study of Crystal Structure and Its Applicability," McGraw-Hill, N. Y., 1927.

Duggar, Benjamin M., "Biological Effects of Radiation," McGraw-Hill, N. Y., 1936.

Symposium on Radiography and X-ray Diffraction Methods, American Society for Testing Materials, Philadelphia, Pa., 1937.

TYPICAL USE—Tubes like this Westinghouse type are used for many industrial x-ray studies

electronics

Tubes have untapped potentialities in research and industry as well as in communications but not all wartime developments will be immediately applicable to peacetime problems and some techniques born of military necessity may never prove economically sound

THE SCIENCE of electronics is at present enjoying merited publicity. Much of this publicity revolves around the virtual certainty and some of it around the mere supposition that technical developments which are helping to win the war will have immediate practical peacetime applications.

While wartime innovations must naturally be kept in mind when attempting to peer into the future it is also true that unless other factors are also considered conclusions may be more apparent than real.

Effects of Two Wars

Electronics has gone through certain definite phases. Up to the time of World War I, it was an activity of scientific interest to just a few research groups. During that war it acquired a practical status which, a few years later, broadcasting transformed into a vast commercial undertaking. Shortly thereafter, applications for vacuum tubes other than communications were initiated but, in general, the reaction was unfavorable in this "first period of glamor." Fragile little radio tubes were not suitable for the rigid requirements of industry.

Then along came the late 20's, when it was again freely predicted that electron tubes would do all sorts of wonderful things. During the depression years some progress actually was made in commercially applying electronics in fields outside of radio. This was because any new thing at that time had to prove itself of real value to be accepted by hard-pressed industry and electronics did this in a certain few definite cases.

World War II has brought the second glamorous stage. In times like the present, when only technical accomplishments count and not the cost or economic soundness of the application, one is apt to forget these latter factors. However, in a peacetime future, these factors may rule out many beautiful electronic schemes that recently have been publicized.

There has also been a tendency of late in publicity to capitalize on the fact that all matter and energy under modern physical concepts is related to the electron. However, the engineer working directly on electron tubes and their applications confines his attention to free electrons which are electrons that he can do something about; in other words, electrons in a vacuum tube. This imposes some very definite application limitations.

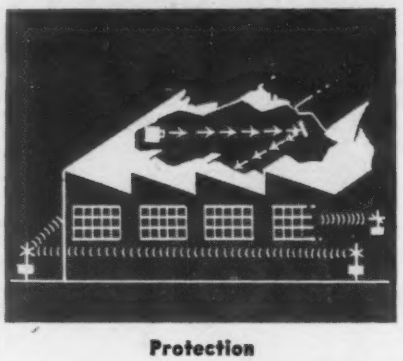
Fortunately, real progress was made not only in the difficult years of the depression but has continued right up to the present war period. This progress will be maintained and bear fruit. Just as, in 1917 and 1918, wartime radio laid the foundation for broadcasting and many of its by-products, the present war is laying a firm technical foundation for other new applications to contribute to post-war times.

The future is not predictable in detail but the general trend does seem reasonably clear. This trend may be grouped under three headings:

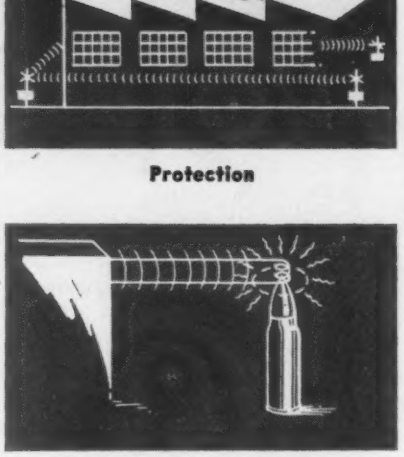
(1) Commercialization of old ideas that had made but little progress up to the outbreak of the present war.

(2) Application of war-inspired technical developments as improvements for old technique.

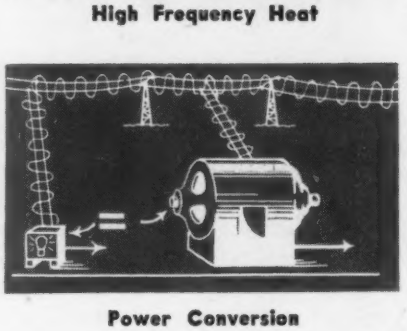
INDUSTRY



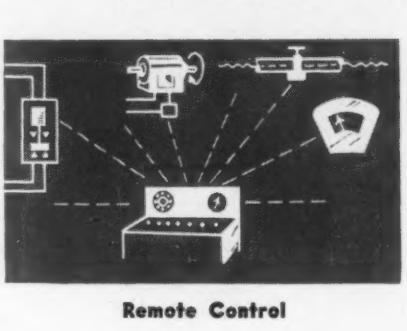
Protection



High Frequency Heat



Power Conversion



Remote Control

PROMISE OF TOMORROW

By W. C. WHITE

Electronics Laboratory
General Electric Company

(3) Radically new electronic de-es and application.

It is obviously impossible to dis- all applications with promise e but the following highlights l serve as a broad guide.

Expansion of Applications

Power Conversion. Rectifiers for tputs between a few hundred tts and a few hundred kilowatts ve enjoyed wide recognition and e abroad for a considerable num- of years. However, in this untry they have made relatively tle progress in competition ainst rotating equipment. The sons for this are somewhat dif- ult to explain but probably could best summed up by the state- nt that conditions differ some- at and that our electrical engi- ers have not been "rectifier nded."

There is a very definite indica- n that this situation is now anging. This is partly due to the t that rectifiers in large sizes n now be obtained on somewhat wer priorities and better de- eries than rotating equipment. It believed, therefore, that the tide s turned in this country and that tifiers will be more widely used this class of service. Thyratrons ll probably be used for the lower wers and sealed, steel-envelope itrons for the range up to sev- l hundred kilowatts. The eco- mics of such rectifiers is now on sound basis.

High-frequency Heating. Heat- g equipment using electron tubes power generators has in the past joyed only limited application. be-equipped heating machines have been used largely in the manufacture of electron tubes themselves. In this case, heating in an electro-magnetic field was employed. Application of high-frequency heating in an electrostatic field was limited almost entirely to therapeutic apparatus of the so-called "fever machine" type.

The advantages of high-frequency heating equipment of both types using, electron tubes, are now being more generally appreciated. Surface hardening of small steel parts has introduced the subject into the industrial field, where it will undoubtedly spread to other applications as it becomes better known and understood.

Heat generated by high frequency equipment is usually expensive heat. This probably means that it will be used in peacetime chiefly where the dollar value of the material to be heated is high per unit of weight or volume. The fact that high-frequency heating can be made selective, so that there is heating of only certain portions or materials of the body in the high-frequency field is also an important factor, the value of which will come to be more generally recognized and utilized. Then, too, certain industrial processes may be effectively handled only by means of high frequency heating.

Motor Control. For a number of industrial applications requiring small electric motors, the d-c motor still has certain desirable characteristics that cannot be duplicated with any type of a-c motor. This is particularly true for certain light machine-tool applications. On the other hand, a-c distribution systems are becoming more universally employed, so that the localities where small d-c motors can be directly utilized are very limited.

The electron tube steps in as an almost perfect solution to this problem. It provides variable voltage d-c from constant potential alternating current. Thus a relatively small piece of additional equipment allows standard d-c motors to be operated with a wide variety of control and automatic features directly from standard voltage a-c distribution lines. Such electronic motor control equipment even provides characteristics not readily obtainable from a straight d-c supply. Tubes have a bright future in this important application.

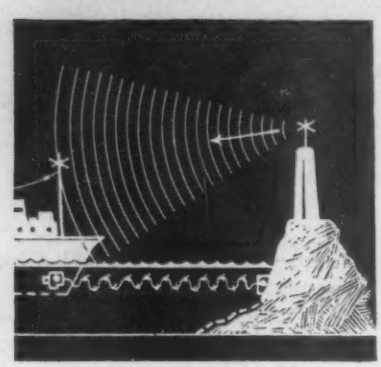
THREE WAR CONTRIBUTIONS

1
Readier acceptance of electronics by industry

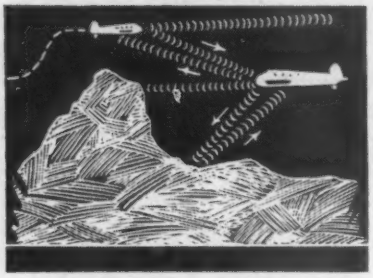
2
Improvement of electronic equipment performance

3
Some radically new electronic developments

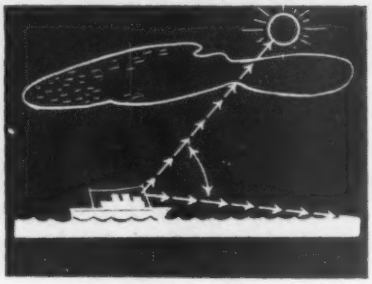
NAVIGATION



Lightless Lighthouse



Anti-Collision Systems



Blind Bearings

A-C Contactors. For the past few years, ignitrons have enjoyed rapidly expanding use in the resistance welding field, where they serve as silent, high-speed a-c switches or contactors free from moving parts and mechanical wear.

As their characteristics and uses become better understood ignitrons will also be employed as a-c contactors, such as controls for electric furnaces.

Continuous Control. In many cases where there is automatic control of electrical equipment the controlling device at intervals switches the power on and off, at full potential, in order that the average over a period of time may be some desired value. This is particularly the case in electric heating. Continuous control is highly desirable for certain applications formerly requiring the use of rheostats or regulators, with their attendant complications. Thyratrons and ignitrons lend themselves well to continuous control due to their ability to be phase controlled cycle by cycle. They should, therefore, have wider application.

Radio. Greater use of the uhf regions is a foregone conclusion. The war has greatly increased our knowledge of how to generate, control and receive these frequencies. Many improvements in television and in FM broadcasting will result.

Use of uhf transceivers, much like the "walkie-talkies", for personal uses is easily possible, for example in camps, between boats and vehicles and to fixed points from these units.

Other Devices. There is another class of electronic device that is sure to play an important part in the future. In this group is the electron microscope, the electron diffraction camera, the electron mass spectrograph, the cyclotron, and the induction electron accelerator. These are all characterized by the fact that they are high-vacuum, high-voltage devices equipped with evacuating pumps. They can be opened up and later re-assembled and re-evacuated.

Improvement of Technique

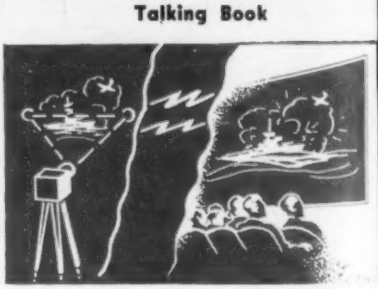
Uses for UHF. The outstanding improvements in technique in the past two years have frequently involved practical utilization of ultrahigh frequencies. There are still several octaves in the gap between what was recently called the very short waves and the infrared region. However, more rapid progress has been made in closing this gap, as regards practical utilization, in the past two years than in the previous ten years. This progress has not only resulted in practical use of these much higher frequencies but in continual increases in the amount of power that can be generated and utilized.

Looked at broadly, these frequencies are chiefly valuable because they utilize much smaller radiating and receiving structures; they can be more easily utilized in the form of narrow beams and they permit a vastly increased number of available channels. Looked at in another way, these factors can al be expressed by saying that the ultrahigh frequencies have more the properties of light than the lo radio waves. For certain applic tions, their use has many of the a vantages of light without certa of the disadvantages. High fr quencies may be generated and r ceived with relatively compact uni and lend themselves readily to u with reflectors and refractor High-frequency beams will al travel farther and can be sent alon conductors and around corners a greater extent than light.

Engineers now working with e tremely high frequencies are in a entirely new environment. The find themselves in much the sam situation as Edison must have be in during his development of t electric light. Not only did Ediso have to develop the incandescen lamp itself, but he had to develo generators, engines to drive the governors, regulators, switchboa instruments, circuit breakers, a other items for the generating st tion. In addition, he had to develo and perfect distribution system and all of the items that go into t premises of the user, such as soc ets, switches, fuses and other wi ing devices. In other words, he h to develop practically a whole ne system. This same thing is tr with the very high frequencie Every element in the system has

ENTERTAINMENT

Talking Book

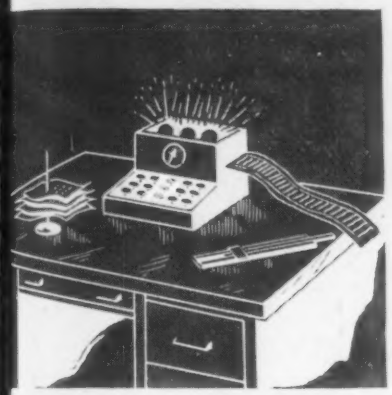


Television Movies

designed virtually from scratch. transmit power even a few feet quires specialized engineering owledge.

UHF vs Light. In many ways, as s been pointed out, ultrahigh fre- encies behave like sound and ht and, therefore, acoustical and tical concepts are often very lpful in understanding ultrahigh- equency phenomena. In a like y, therefore, it is reasonable to sume that some of the uses of trahigh frequencies will be along e lines of applications that now ilize optical phenomena. The ob- ous ones, of course, are in connec- n with navigation, where optical struments have been commonly ployed. In cases of this sort, it is asonable to suppose that an ultra- gh-frequency transmitter, a beam diator, and a receiver incorpo- ting an amplifier may take the ace of the sun, mirrors, lenses,

BUSINESS



Electronic Calculator

d the human eye, enhanced by a ld glass or telescope. In other ords, we could have the electronic uivalent of a telescope with cross airs. We could use an electronic ethod equivalent to sighting on an ject to determine its angular rela- on to some point of reference.

Over the past few years, light eams employed in conjunction ith photoelectric relays have en- yed an increased usefulness in dustry. In a similar way, uhf eams may well find some applica- ons in industry somewhat along e lines of photoelectric relays but plied where light will not func- on due to the fact that it will not through certain materials or will ot readily carry a sufficient dis- nce. It must also be remembered that when employing light we can utilize only a few colors for selective purposes, whereas in the high frequency radio spectrum tuning methods permit the use of a tremendous number of non-interfering wavelengths.

UHF Relaying. Ultrahigh frequencies will undoubtedly be used to an increasing extent in connection with broadcasting and television, for the relaying of programs between studio and transmitter as well as from city to city to accomplish chain broadcasting.

UHF in Medicine. The ultrahigh frequencies open up an entirely new field of research in the medical field due to the fact that devices for applying these high frequencies can be made so small that heating effects can be highly localized. This is not possible at the longer wavelengths. It is also possible that very high frequencies will be found to have some effects on tissue and bacteria other than heating and that these effects may be selective.

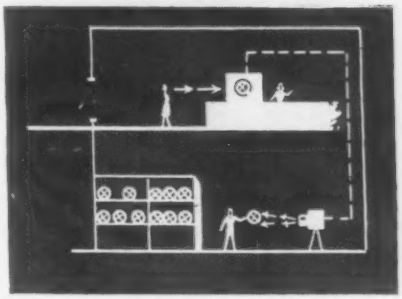
In the field of medicine, however, we must expect that the results obtained will be relatively slow in being established because of the many complications involved.

UHF-Trained Manpower. Tens of thousands of men who have joined the military services or are in Government employ are acquiring knowledge and experience on electron tubes and electronic devices at ultrahigh frequencies. These men cover the whole field. At one extreme are highly skilled scientists, both theoretical and experimental, who are becoming interested in some phase of the subject. At the other end of the scale are relatively unskilled men who are now being taught the maintenance equipment. In between these extremes are many other classifications involving both technically trained men and non-technically trained men.

It is possible that at the end of the war a situation may arise which is quite unusual. In the past, when men have returned from military service they have almost always had to adapt themselves to new occupations and new devices and machines. This has meant that these returning men were at a disadvantage in comparison to the men who stayed behind in re-establishing themselves. Perhaps the situation will be reversed in this case and these thousands of men with knowledge and skill along UHF electronic lines will return home with up-to-the-minute knowledge so that those who remained at home in industry will be at a relative disadvantage and will have much to learn to keep abreast in the electronic field.

COMMUNICATION

Personal Portables



Pictures by Wire

Radically New Applications

C-R Tubes. The points that have been raised in connection with the use of ultra high frequencies bring to mind the principle that whenever work has been done in science to make something many times smaller, bigger, faster, slower, heavier or lighter than previous accomplishments, then a host of new opportunities are opened up for research and utilization. Recent work inspired by the war has done this very thing by increasing the range and availability of the very high frequencies and, therefore, it is certain that we can expect some radically new applications.

This is a field, however, in which it is inadvisable to be definite. By really new applications is meant something like broadcasting, which introduced major changes into every-day living. It appears reason-

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WAR PRODUCTION

Theme of IRE-AIEE Conference

Engineering papers stress war production, standardization, specifications and simplification as engineer's contribution to war effort. How to get most out of tubes, and manpower problems discussed. W. Wilson received I.R.E. Medal of Honor

RADIO'S PLACE IN THE WAR was the theme of the conference of the Institute of Radio Engineers held in New York on January 28, at which many of the country's leading communication engineers gathered to discuss production, standardization, and other topics of current interest. The heavy load imposed on electronic and radio personel, in which field there exists an acute manpower shortage, together with shortages of traveling facilities, necessitated telescoping the usual three-day convention into the activities of a single day. Another innovation, inaugurated this year, was the holding of the I.R.E. Conference jointly with the American Institute of Electrical Engineers, whose National Technical Meeting was held during the entire week of January 25 to 29.

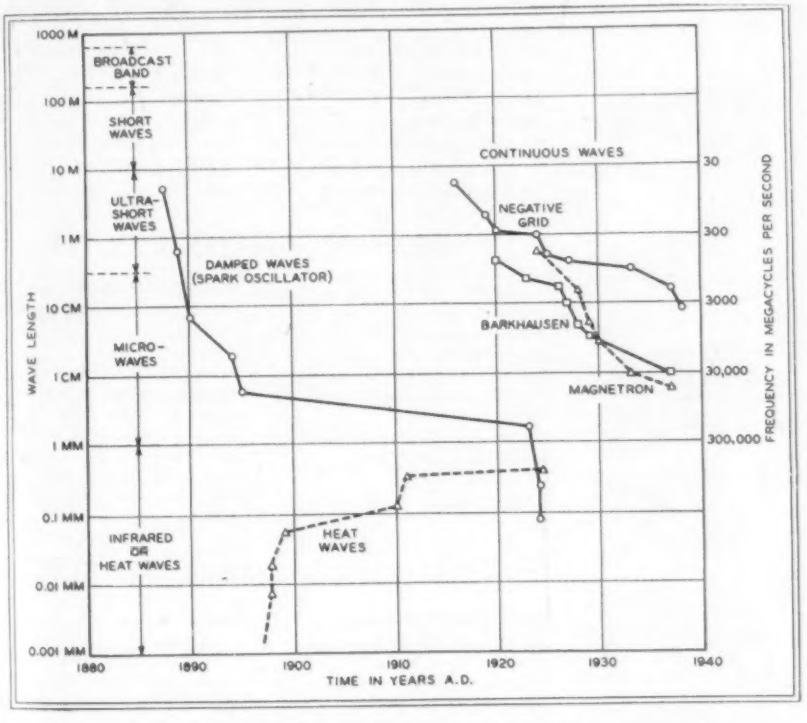
Broadly speaking, the program for the Conference was divided into two main divisions: (1) I.R.E. business activities and non-technical discussions, and (2) the presentation of papers, most of which dealt with problems of production of equipment for military requirements.

At the business meeting early in the afternoon A. F. Van Dyck, president for 1942 gave an account of his term of office and noted the trend of the Institute's accomplishment for the past year. At the end of the year, 8,775 persons were members of the I.R.E., a New York Section had been formed during the year and several changes in personnel had taken place in the headquarters office during 1942. The most notable of these, namely, the resignation of H. P. Westman, secretary, to devote full time to standardization activities in the war program of the American Standards Association, has already been reported in ELECTRONICS. The important activities of the Institute in a program of simplification and standardization were also outlined by Mr. Van Dyck who indicated that it was his belief that 1942 recorded the end of one era in radio communication and the beginning of another.

In concluding his report, Mr. Van Dyck turned the meeting over to Dr. L. P. Wheeler, president of the Institute of Radio Engineers for 1943. Mr. F. S. Barton, IRE vice president for the current year was also inducted into office. Dr. Wheeler's first official duty was the awarding of the Institute's Medal of Honor to William Wilson in recognition of distinguished service in radio communication. Fellowships of the Institute were conferred on the following engineers: Andrew Alford, Ivan S. Coggeshall, Captain Jennings B. Dow, Lee A. DuBridge, Peter C. Goldmark, Daniel E. Harnett, Dorman D. Israel, Axel G. Jensen, George F. Metcalf and Irving Wolff.

The Institute's business and social activities were resumed at 10:15 p.m. when Sir Noel Ashbridge, chief engineer of the British Broadcasting Corporation, addressed Institute

(*Continued on page* 272)



Development of high frequency oscillating circuits during the past half century. Curves at the left represent frontiers established mainly by physicists. Curves at the right represent primarily the "homesteading" activities of engineers, according to Dr. C. G. Southworth

a Look Ahead AT ELECTRONICS BY

and a Directory of G-E *Electronic* Products

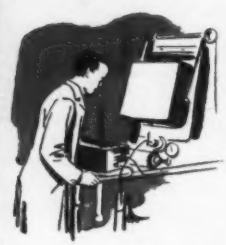
RADIO, TELEVISION, AND COMMUNICATION EQUIPMENT

- AM broadcast transmitters
- AM broadcast receivers
- Carrier current
- Electronic tubes
- FM broadcast transmitters
- FM broadcast receivers
- FM police and emergency radio
- Measurement equipment
- Military equipment
- Monitors
- Studio equipment
- Television transmitters
- Television receivers
- Transmitting antennas

INDUSTRIAL ELECTRONIC DEVICES

- Amplifiers
- Arc-welding control
- Atomic-hydrogen welding control
- Battery chargers
- Cable-fault locator
- Electric-furnace control
- Electronic timers
- High-frequency power oscillators
- High-voltage rectifiers
- Industrial X-ray
- Magnetizers
- Photoelectric control for: blackout, sabotage prevention, inspection, printing and we register, lighting
- Photoelectric relays
- Photoelectric pyrometers
- Power rectifiers
- Resistance-welding control
- Synchronous-motor exciters
- Theater-lighting control
- Variable-speed motor drive
- Voltage and current regulato

ELECTRONIC MEASURING EQUIPMENT



- Cathode-ray oscilloscopes
- Electron microscopes
- Power bridges
- Regulated power supplies
- Servo-sweep generators
- Signal-to-noise ratio meters
- Square-wave generators
- X-ray diffraction camera
- Devices to measure: resistance, capacitance, indu tance, impulse voltages, tran sients, coil turns, short circuit turns, thickness, pressure, strai color, vibration, sound leve reflectance, light transmissio acceleration, rotational spe

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General Electric Supply Corp.

CONNECTICUT

Bridgeport
General Electric Supply Corp.
Hatry & Young

Greenwich
Greenwich Electrical Co.

Hartford
General Electric Supply Corp.
Hatry & Young

New Haven
General Electric Supply Corp.
Hatry & Young
Congress Radio Company

Waterbury
General Electric Supply Corp.

DELAWARE

Wilmington
General Electric Supply Corp.
Delaware Radio Sales Co.

DIST. OF COLUMBIA

Washington
General Electric Supply Corp.

FLORIDA

Jacksonville
General Electric Supply Corp.

Miami
General Electric Supply Corp.
Electric Radio Eng. & Sy. Co.

St. Petersburg
Radio Hospital & Parts Store

Tampa
General Electric Supply Corp.

GEORGIA

Atlanta
General Electric Supply Corp.
Lafayette Radio Corp.

Savannah
General Electric Supply Corp.

IDAHO

Boise
General Electric Supply Corp.

ILLINOIS

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General Electric Supply Corp.
R. Cooper, Jr., Inc.
Allied Radio Corp.
Chicago Radio Apparatus Co.
Newark Electric Co.
Lafayette Radio Corp.

Quincy
Crescent Elec. Supply Co.

Rockford
General Electric Supply Corp.

Rock Island
Tri-City Radio Sy. Co.

Springfield
General Electric Supply Corp.

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Evansville
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Fort Wayne
Protective Elec. Sy. Co.
Pembleton Laboratories
Radio Parts Co.

Indianapolis
General Electric Supply Corp.
Van Sickle Radio Co.

Muncie
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South Bend
South Bend Electric Co.

Terre Haute
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IOWA

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Des Moines
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Dubuque
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Mason City
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Sioux City
Crescent Elec. Supply Corp.

Waterloo
Crescent Elec. Supply Corp.

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Radio Laboratories

Topeka
Radio Laboratories

KENTUCKY

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Universal Radio Supply Co.

LOUISIANA

New Orleans
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Shreveport
General Electric Supply Corp.

MAINE

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General Electric Supply Corp.
Rice & Tyler

Portland
General Electric Supply Corp.
Bartlett Radio Company

MARYLAND

Baltimore
General Electric Supply Corp.
Radio Electric Service Co.

Cumberland
Morrissey's Radio Sy. Co.

Hagerstown
Zimmerman Wholesalers

MASSACHUSETTS

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Brattle Radio Co.
Radio Wire Television, Inc.
The Radio Shack Corp.

Springfield
General Electric Supply Corp.
T. F. Cushing Co.
Springfield Radio Co.

Worcester
Coghlin Electric Company
General Electric Supply Corp.
Radio Maintenance Sy. Co.

MICHIGAN

Ann Arbor
Purchase Radio
Wedemeyer Radio Co.

Battle Creek
Wedemeyer Radio Co.

Detroit
General Electric Supply Corp.
M. N. Duffy & Co.
Radio Specialties Corp.

Grand Rapids
General Electric Supply Corp.

Jackson
Fulton Radio Sy. Co.

Kalamazoo
General Electric Supply Corp.

Lansing
General Electric Supply Corp.
Knight Elec. Co.

Muskegon
Fitzpatrick Elec. Supply Co.

Saginaw
General Electric Supply Corp.

St. Joseph
St. Joe Radio Co.

MINNESOTA

Duluth
General Electric Supply Corp.
Northwest Radio

Minneapolis
General Electric Supply Corp.

St. Paul
General Electric Supply Corp.
Hall Electric Company

MISSISSIPPI

Jackson
General Electric Supply Corp.

MISSOURI

Joplin
General Electric Supply Corp.

Kansas City
General Electric Supply Corp.
Radio Laboratories

St. Louis
General Electric Supply Corp.
Van Sickle Radio Co.
Gordon Radio Company
Walter Ashe Radio Company

MONTANA

Butte
General Electric Supply Corp.

NEBRASKA

Omaha
General Electric Supply Corp.
Radio Equipment Corp.

NEW HAMPSHIRE

Concord
Carl B. Evans

NEW JERSEY

Jersey City
General Electric Supply Corp.

Newark
General Electric Supply Corp.
Aaron Lippman & Co.
Radio Wire Television, Inc.

New Brunswick
Aaron Lippman & Co.

Paterson
General Electric Supply Corp.
Aaron Lippman & Co.

NEW YORK

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Fort Orange Radio Dist. Co.

Binghamton
So. Tier Electric Sy. Co.

Brooklyn
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Buffalo
General Electric Supply Corp.
Dymac Radio Co.

Elmira
So. Tier Electric Sy. Co.
Barker, Rose & Kimball, Inc.

Ithaca
Stallman of Ithaca

New York City
Metropolitan Dist. Branch,
General Electric Company
General Electric Supply Corp.
Harrison Radio Co.
Harvey's Radio Shop
Radio Wire Television, Inc.
Sanford Samuel Corp.
Sun Radio Company
Terminal Radio Corp.
Service Radio Engineers

Niagara Falls
General Electric Supply Corp.

Plattsburg
Bragg Bros.

Poughkeepsie
Electra Supply Co., Inc.

Rochester
General Electric Supply Corp.
Beaucaire, Inc.
Radio Parts & Equip. Co.
Brown Radio Service & Lab.
Masline Radio Parts

Rome
Radio Service Lab.

Syracuse
Gould-Farmer Co., Inc.
W. E. Berndt

Utica
Langdon & Hughes Elec. Co.
Vaeth Electric Company

NORTH CAROLINA

Asheville
Freck Radio & Supply Co.

Charlotte
General Electric Supply Corp.
Shaw Distributing Co.

Greensboro
Johannesen Electric Co.

NORTH DAKOTA

Fargo
Dakota Electric Supply Co.

OHIO

Akron
General Electric Supply Corp.
Brighton Sporting Goods Co.

Canton
Furbay-Sommer Company
Burroughs Radio Company

Cincinnati
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Jos. N. Davies
United Radio, Inc.

Cleveland
General Electric Supply Corp.
Progress Radio Supply Co.
Radio Serviceman's Sy. Co.

Columbus
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Dayton
General Electric Supply Corp.
Crosley Distributing Corp.

Kent
Kladag Radio Labs.

Lima
Lima Radio Parts Co.

Toledo
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Youngstown
General Electric Supply Corp.

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Southern Sales Co.

Tulsa
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Radio, Inc.

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PENNSYLVANIA

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Erie
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Warren Radio Co.

Harrisburg
Raub Supply Company

Lancaster
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Nashville
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Amarillo
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Corpus Christi
Strauss-Frank Co.

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Southwest Radio Service
Wilkinson Bros.

Denison
Denison Radio Lab.

El Paso
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C. C. McNicol

Fort Worth
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Fort Worth Radio Supply Co.

Houston
General Electric Supply Corp.
Strauss-Frank Co.

San Antonio
General Electric Supply Corp.
Strauss-Frank Co.

UTAH

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General Electric Supply Corp.
Radio Supply, Inc.

VIRGINIA

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General Electric Supply Corp.
Radio Supply Co.

Richmond
General Electric Supply Corp.

WASHINGTON

Seattle
General Electric Supply Corp.

Spokane
General Electric Supply Corp.

WEST VIRGINIA

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Virginian Electric Co., Inc.
Hicks Radio Supply Co.
Sigmon Radio Supply Co.

Wheeling
Cameradio Co.

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GENERAL ELECTRIC

176-B1

 (*Continued from page 91*)

on a voice-frequency basis was accompanied by a large increase in the number of telephone repeaters as indicated in the table.

Carrier Systems

The idea of deriving more than one circuit from a communication path is an old one. In fact it was in connection with experiments on a multi-channel carrier telegraph system that Alexander Graham Bell invented the telephone and one can well imagine that the possibilities of multi-channel operation tempted the early telephone engineers. To provide two circuits on a pair of wires, it is necessary to transmit a band of frequencies at least twice as wide as that which could be used for one circuit. Since the transmission loss of practically all types of line structures in general use increases as the band of frequencies is increased, one of the major obstacles to the early provision of a multi-channel system was the lack of a suitable amplifying device to compensate the added losses encountered in that method of operation. The development and improvement of the electronic amplifier, therefore, opened the way for the practical carrier system. The first of these systems was placed in service in 1918 on open wires between Baltimore and Pittsburgh. At that time the bulk of the really long haul circuits was open-wire construction, using heavy gauge wires. Whereas the introduction of the voice-frequency repeater made possible the use of smaller wire sizes in cables with accompanying savings in cost, the extent to which the size of the conductors of open-wire circuits could be reduced became limited then not by transmission but by the physical strength required to withstand the strains of that type of construction. It was but natural, therefore, that the first application of carrier methods was to open-wire circuits for here, because of the lengths involved and the relatively heavy copper conductors, the greatest economies were obtainable. For many years three carrier channels was the maximum number which could be operated on the line conductors over and above the voice-frequency circuits. By 1939, however, modern amplifier technique and improved line construction methods made it possible to operate a 12-channel carrier system simultaneously with the older three-channel carrier and voice-frequency circuits, making a total of 16 circuits on a single open-wire pair.

With the ever increasing requirements for circuits, the urge to operate multi-channel carrier telephone systems on cable pairs became more desirable, but the problems imposed by this method of operation were many and varied. Whereas with the single voice-frequency circuit operation over cables a total over-all line loss of more than 1,000 decibels is not unusual, multi-channel carrier operation would increase this loss many times. The problem of matching this huge loss with a correspondingly huge amplification to a precision of one or two decibels was a problem of no small magnitude, but the advancing electronic technique was equal to solving it. Mr. H. S. Black of the Bell Telephone Laboratories invented a new type of amplifier employing the principle of negative feed-back in which stability and fidelity of transmission of amplifiers may be improved several hundred fold. It is this type of amplifier which is used in the so-called cable carrier sytems and, indeed, in most of the other modern amplifier applications as well.

The cable carrier system provides 12 telephone circuits from two pairs of 19-gauge wire, one of which is used for transmission in one direction and the other for transmission in the opposite direction. This system may be applied to cables designed and placed especially for carrier operation or to the small gauge cables which were placed initially for voice frequency operation. In recent years new long-distance cables have been designed primarily for carrier operation.

WAVE GUIDE—G. C. Southworth, holding one of the resonant chambers used for tests of wave guide transmission. Behind him are two experimental wave guide transmission lines at the Holmdel Station of Bell Telephone Laboratories

Cable Across the Continent

Among the recently completed cables was the last link between the vast cable network covering the eastern half of the country and the growing cable network on the Pacific Coast. The twin underground cables recently completed between Omaha and Sacramento are designed for cable carrier operation and provide

about 500 telephone circuits from the 54 pairs of wire contained in each cable. As of December 1942, it is now possible to talk entirely over cable facilities from Bangor, Maine to San Diego, California. On such a connection, the speech currents travel nearly 4,000 miles, pass through more than 200 amplifiers with a total of over 600 vacuum tubes in tandem. The overall line attenuation on such a connection would be well over 10,000 decibels. The control of this amplification is accomplished automatically by means of electronic devices with the result that the circuits of today, such as that cited above, have a stability unequalled in the days before the vacuum tube.

Radio Extensions of Wire Circuits

Although most of the telephone and telegraph communication plants in this country employ wire systems, radio is extensively used to reach points overseas, ocean liners at sea, smaller ships in coastal and inland waters, for emergency telephone service, and in other special applications such as the bridging of natural barriers. The first overseas telephone service was inaugurated in 1927 between New York and London. This development represented an extension of the experiments undertaken in 1915 which were interrupted by the war. Since 1927 radiotelephone circuits have been extended to practically all parts of the world and today, except for the war, it would be possible to reach 83 foreign countries and overseas areas and for any telephone in the United States to connect with 93 percent of the world's telephones. Prior to the war, radiotelephone service was available to 24 luxury liners on the principal trade routes of the world. Service to boats in coastal and inland waters which was introduced in 1932 has now grown to 27 stations serving about 3,000 boats.

The techniques employed in these radio system are for the most part outgrowths and extensions of those employed in carrier telephony. Here again, as in the case of wire telephony, the advantages of multi-channel operation were significant, and advanced techniques have made possible a type of operation in which radio transmitters and receivers are used by a number of channels simultaneously. Arrangements of this type are now in use on nine of the regular radio-telephone links.

One of the recently developed carrier systems—the coaxial system—employs a specially arranged transmission path over which hundreds of circuits can be obtained. This structure consists of a central conductor arranged coaxially with an outer hollow tube about ½ inch in diameter. One such unit is used for transmision in each direction and a second pair of units is provided for standby operation. The repeaters on this system are spaced at intervals of about 5 miles and employ amplifiers which transmit a frequency band of several megacycles. This system is not yet in extensive use and is employed for only a few hundred circuits. Another transmission system using an unusual type of line structure is the wave guide system in which waves are transmitted along hollow conducting tubes. The wave guide system is still in the research stages and has not been placed in practical operation in the telephone plant. This system employs frequencies in the order of thousands of megacycles and has required the development of new types of vacuum tubes and associated systems.

Developments in Vacuum Tubes

When it is considered that each one of the hundreds of vacuum tubes in tandem on long-haul telephone connections has its individual responsibilities for getting the message through, or that a single tube in a carrier repeater controls the destiny of 12 circuits, it is seen that the application of the vacuum tube to the telephone plant has been accompanied by improvements and changes in design leading to a long life and a high degree of uniformity, stability and reliability.

As a result of continuous research the life expectancy of the most widely used filamentary type triode is now five years of continuous operation 24 hours a day. Certain tubes have longer life and the indirectly heated cathode type pentodes used for most present-day carrier systems have an expectancy of two years of continuous operation.

Future Possibilities

Any effort to foretell the future must be very general since changing conditions, together with unforeseen developments, may make significant changes in the course of developments. The present trends are in the direction of the use of higher and higher frequencies providing broader bands and larger numbers of circuits over a given path. Continuing this trend will impose more severe requirements upon vacuum tubes and the associated circuits and will require the development of new types of tubes, particularly where wave guide and ultrahigh frequency radio operation is concerned. Present systems are sufficiently stable to permit operation on an essentially automatic basis going for long periods without maintenance visits. As vacuum tube development results in greater stability, the future may expect to see electronic devices located in quite isolated places and remotely controlled. Serious thought has been given to the design of a submarine cable with built-in repeaters housed in an enlarged splice. Such a system was described in the Kelvin Lecture by Dr. Oliver Buckley, President of the Bell Telephone Laboratories, and presented for him before the Institution of Electrical Engineers in London, April 23, 1942.

Power for the undersea repeaters would be supplied from the terminals in somewhat the same manner as power for the auxiliary repeaters, located at intervals of about 5 miles on coaxial cable, is supplied over the cable from main repeater stations located about 50 to 75 miles apart.

High Power Not Necessary on UHF

Another significant trend is the use of lower power output from amplifiers and radio transmitters even on the multi-channel systems. As higher and higher frequencies accompanied by increased numbers of intermediate amplifier points are used, the power output consistent with balanced design will tend to be reduced even further. Although there can be no certainty of it, it is not unlikely that future systems, especially those employing wave guide or ultrahigh frequency space radio, may operate at very low powers and obtain their power from small batteries not unlike those employed in the portable radios today.

When peace opens the door for the more extensive application of newly developed techniques, the part of electronics in communications seems destined to be an important one.

TELEGRAPHY . . . SEE PAGE 166

ELECTRONIC TUBES . . . in Wire Telegraphy

By ALDER F. CONNERY
Chief Engineer,
Postal Telegraph-Cable Company

ELECTRON tubes are widely used in the wire telegraph systems in the United States, and it is but natural that the Postal Telegraph-Cable Company, which operates a nation-wide wire communication system throughout this country, should employ electronic means to a large extent.

Power Packs. Direct current is required for the supply of the various signalling circuits in the telegraph offices. In the largest offices motor-generator sets are used for converting the alternating-current supply to direct current. In the moderate sized and smaller offices the conversion from a.c. to d.c. is accomplished by means of power-packs which use mercury-vapor tubes for the rectifying element. The design of the rectifying units for the supply of telegraph currents must be such that not only is the output voltage constant within very small limits under varying load but there must not be any appreciable voltage change at the instant that heavy drains are applied or removed. Power-pack units that meet the severe requirements have been standardized in various sizes and have made small motor-generators obsolete in the telegraph field. Among the advantages of the rectifiers over the motor-generators are freedom from noise, freedom from radio interference and greatly reduced amount of routine maintenance.

Carrier Telegraph. Between New York City and Washington, D. C. a ten-channel audio-frequency telegraph system is in constant use. Generation of the audio tones is produced by a motor driven multi-frequency tone generator. Vacuum tubes are used at the terminals for detection and amplification. At the three repeater points vacuum tubes are used as amplifiers in the unidirectional repeaters.

Telephone Repeaters. Postal Telegraph owns and operates a number of toll telephone systems in various sections of the United States. All of the longer circuits contain one or more repeaters. These repeaters are all a-c operated and vacuum tubes are used as amplifiers and rectifiers.

Carrier Telephone. In addition to the physical toll circuits, Postal has a number of superimposed telephone carrier channels. A frequency of 7 kc in one direction and 10.5 kc in the opposition direction is standard. Vacuum tubes are used in the carrier terminal sets as oscillators, modulators, amplifiers and rectifiers. The longer carrier circuits are equipped with one or more carrier repeaters in tandem, and vacuum tubes, of course, are used as amplifying devices.

Induction Neutralizing. On several important pole lines the close proximity of high voltage power parallels for long distances have made it necessary to provide special protective methods to permit normal use of the wires. One conductor on the pole line is selected for use as a pilot wire and this is connected to an induction neutralizing device at the repeater station which tends to feed back into each wire on the pole line a current equal in intensity and opposite in direction to the disturbing current and thus effectively neutralizing the disturbing current. The induction neutralizing uses a considerable number of vacuum tubes.

Metallic Telegraph. For many years telegraph traffic between the larger centers of population has been carried over "multiplex" equipment. Two or three channels are derived by means of synchronously rotating distributors which divide the line time at regular intervals among the several channels. This multiplex equipment was operated over ground-return duplexed wires. In recent years the increase in the number of electric power distributing systems paralleling the grounded multiplex circuits has seriously reduced the efficiency of these circuits. Ground-return telegraph circuits are also seriously affected by disturbances from adjacent telegraph circuits and also, at infrequent intervals, by circulating currents resulting from aurora-borealis displays.

Metallic telegraph circuits in which two line conductors are used instead of a single conductor with ground return have been designed but heretofore have not been very successful. The electro-mechanical relay necessary for handling the received signal requires a certain minimum current for efficient operation on high-speed signals. Using a reasonable value of transmitting voltage, 120 to 160 volts, insufficient current is transmitted over the loop of wire between repeater stations if they have the normal spacing (250–300 miles). The receiving relay operation was inefficient and severe distortion to the signals was the inevitable result. Higher sending voltages have been tried but difficulty is experienced in controlling the high voltages at the sending end without introducing severe signal distortion.

Postal Telegraph has solved this problem of designing an efficient metallic telegraph circuit by the novel use of a pair of electron tubes to drive the receiving polarized relay. With this circuit, the relay will be operated by a current of the proper value for efficient operation regardless of the value of current in the loop circuit. A further advantage of the system is that the reactance of the relay windings does not appear in the loop circuit and therefore does not complicate

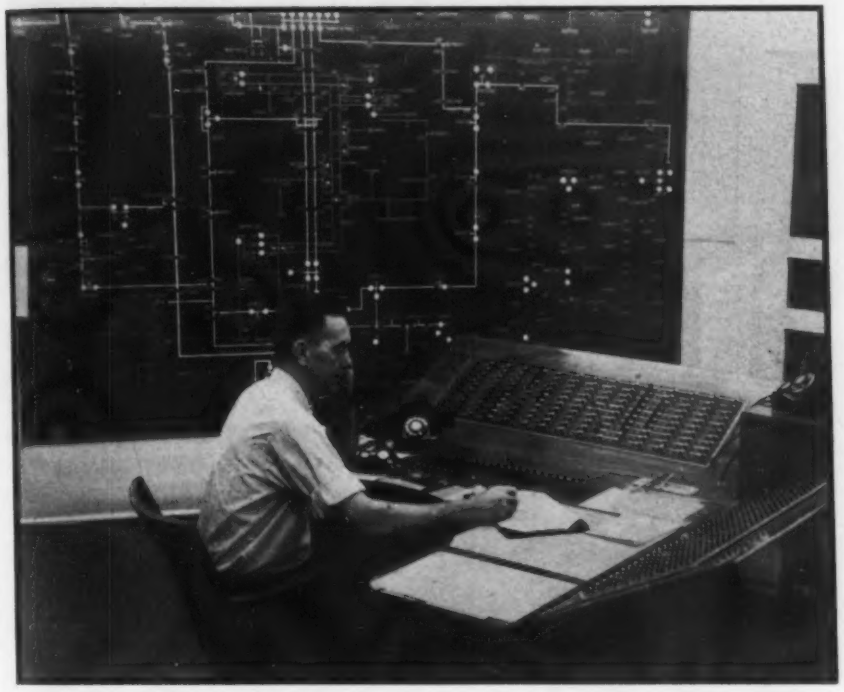
(*Continued on page* 258)

(*Continued from page* 135)

the power and telephone can be rerouted in the event of a line failure at any other point. In other words the power and associated telephone system becomes a series of loops, or lines which can be connected as loops if necessary. The telephone circuits, of course, would not normally be connected in loops but the communications can be rerouted in event of the loss of any one section.

When a line failure does occur for any reason, some systems now use carrier remote control to aid in quickly locating the bad section of line. Carrier controlled switching stations are installed along the lines so that it becomes only a matter of dialing a number from the supervisory desk to open or close a remote switch. In this way, it is possible to quickly determine the approximate location of the line fault and drop out that section of line. The remote control method accomplishes in a matter of a very few minutes what might take many hours if a patrolman had to go to each sectionalizing switch to operate it manually.

Another unique electronics application is a method now used for determining the location of a line fault from the substation or point of termination of the line in question. The device consists essentially of a variable frequency oscillator which feeds radio frequency power into the line under test. A meter in the oscillator circuit measures the current fed into the transmission line. By varying the frequency steadily in one direction, standing waves are set up on the transmission line. The line fault constitutes an impedance irregularity which causes reflection and standing waves result at certain frequencies. The separation in the frequencies at which standing waves are set up on the line supplies all the information necessary to calculate the distance to the line fault. The frequency-versus-line-current-curve is automatically recorded by the machine.



SWITCHING—R. Penhale, dispatcher for the Montana Power Company, seated at the main control desk. The open or closed position of every oil switch and air-break switch in the system is indicated on the diagram board. This is the electrical center of 5000 miles of power transmission line and an equal length of carrier-current switching and telephone circuit

The greatest portion of power system electronic development is involved directly or indirectly with power transmission. Electric power is so very important that constant vigilance is required by many people to keep the power on the lines. The continuity of power flow is aided in many ways by electronic devices but there is much to be done before the field is fully developed.

From the standpoint of communication, the telephone network folowing the transmission lines becomes very long with high signal attenuation as the result. This is true especially with the large spreadout systems in the west where so much distance is covered over the more sparsely settled areas. The high attenuation of the signal in combination with the usual noise level makes many telephones impractical to use without the aid of electronics.

Communication in Power Systems Aided by Electronics

The most recent electronic telephone development for power system use, is a special form of repeater. This arrangement combats high noise levels, and attenuation, very successfully. It operates through the private branch exchange board of either the manual or automatic type. The fundamental principle is high level transmission with fixed attenuation in the receiving end of the circuit. By this system signal is "traded" for noise and extremely noisy lines become excellent communication circuits.

A very popular electronic application now used by power systems is represented by the special emergency radio systems. These radio networks are normally used for standby communication to supplement or replace the telephone system if the latter is put out of service or is inadequate during an emergency.

The Special Emergency license permits the use of radio during emergencies or for contacting patrolmen and repair crews when other communication is out of service or inadequate. This standby communication becomes especially valuable during heavy storms which may cover much territory and destroy several lines at one time. Radio communication speeds up the ordering out of the necessary crews and material for repairing the line breaks. Also, radio is used to report the com-

pletion of the job so the line can be quickly restored to service.

Carrier Current Applications

The application of carrier current to power lines has had little publicity outside of the power field. The result is that the average man not in contact with that work has had no opportunity to become acquainted with it. Much of the equipment is similar to conventional radio transmitter and receiver design, still several special circuits are necessary to adapt the principles of radio to power line use.

Carrier current constitutes one of the most important electronic applications in the power field. It would be classified in the low power branch and in some cases could be classed as medium power. The uses of carrier on power systems seem almost unlimited so that it promises to be of far greater value in the future than it is at present. Some of the important carrier applications are telephony, telemetering, relaying, supervisory control, phase angle control and load control.

The most popular telephone arrangement is the single-frequency automatic. This is a voice operated changeover from receive to transmit. Recent voice switching circuits are entirely electronic and operate so rapidly that clipping is unnoticed. An automatic dialing system is used for calling the desired party. A few two-frequency carrier sets are in use where only two stations are required.

Carrier telemetering is used for transmitting to a distance, such readings as voltage, current, wattage, pressure, temperature, water level and frequency. The transmitter is tone-amplitude modulated, interrupted or frequency-modulated as the case may be, by the instrument indicating the value measured. At the receiving end the proper discriminator or impulse filter translates the modulated carrier to a direct current proportional to the distant measured value.

Phase-angle control and load control are accomplished in about the same manner as telemetering except that the received signal controls, through additional circuits, either the frequency or voltage respectively. When two or more power systems are interconnected it is sometimes difficult to maintain the desired power flow through the tie line. In some cases the carrier phase-angle control is used to measure the relative phase angle of the systems and then to automatically shift the frequency of a key generating plant to maintain the optimum phase relation. Load control operates similarly except that it is on a power basis. In this case the controlled station shifts the voltage in a direction to maintain the desired power flow through the system interconnection.

Carrier relaying is used in conjunction with high speed protective relaying systems. The carrier signal is used to prevent operation of all relays except those nearest the line fault. Thus the bad section of line is dropped out of service with a minimum disturbance of the system. The carrier transmitter at a relay station is started by the power relay action if the line fault is not located between that station and the adjacent one. The receiver at the other end of that section of line then blocks the power relays from operating.

DETECTION—Metal locator, equipped with an electronic amplifier. It facilitates the finding of buried pipe lines and valves

Supervisory control systems use carrier signals as a means of remote control for opening and closing switches, operating voltage and speed controls, etc. One popular use of carrier is the control of street lights from a centrally located substation so that a blackout can be accomplished in a minimum of time. A combination of carrier remote control and telemetering allows complete supervision and control of a distant substation or generating plant.

Miscellaneous Applications

Another weak-current application in common use by power systems is the photo tube and circuit. Most of these applications are more or less standard. However, there are a few specialized circuits which appear from time to time for solving the individual problems that arise.

The hole in the meter-scale idea is often used in power work. The meter needle or indicator breaks a beam of light at a predetermined setting and operates the phototube relays and associated equipment. The principle can be used for regulation of current or voltage, over-or under-voltage and current alarms, and numerous other similar devices.

Many electric utilities now use a commercial phototube device for testing and adjusting wattmeters. A beam of light is projected against the rotating wattmeter disk so that the holes in the disk allow light to fall on a phototube. An electronic circuit counts the impulses and after a definite number of impulses are received, a relay turns off the power to the wattmeter and standard test meter. Checking meters by this method eliminates the human element in timing and counting revolutions and is entirely automatic.

A variation of this principle uses a circle of holes in the rotating disk of wattmeters. A beam of light is projected against the meter disk so that the holes in the disk permit light impulses to fall upon a phototube as the disk revolves. The phototube relay impulse frequency is proportional to the power flowing in the wattmeter. The impulses can be sent to a distant point by wire or carrier channel. At the receiving end an impulse filter translates the impulse frequency into a direct current and the wattage is then indicated on a properly calibrated d-c instrument. By such methods of telemetering the system operator knows the load values in the various lines without the necessity of an attendant at each wattmeter. It is often important to know these power

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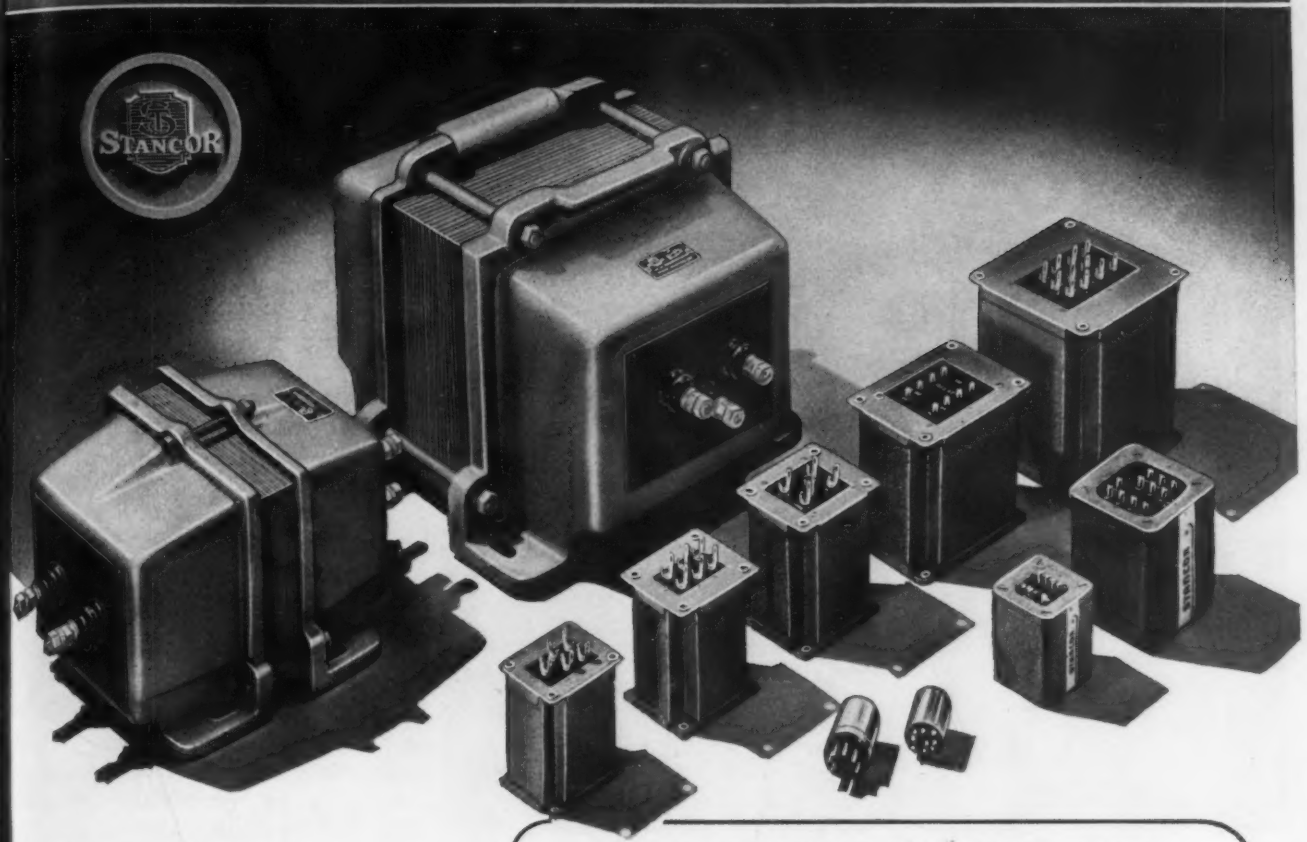

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values instantly and without the delay which would result from values read by an attendant and telephoned to the system operator.

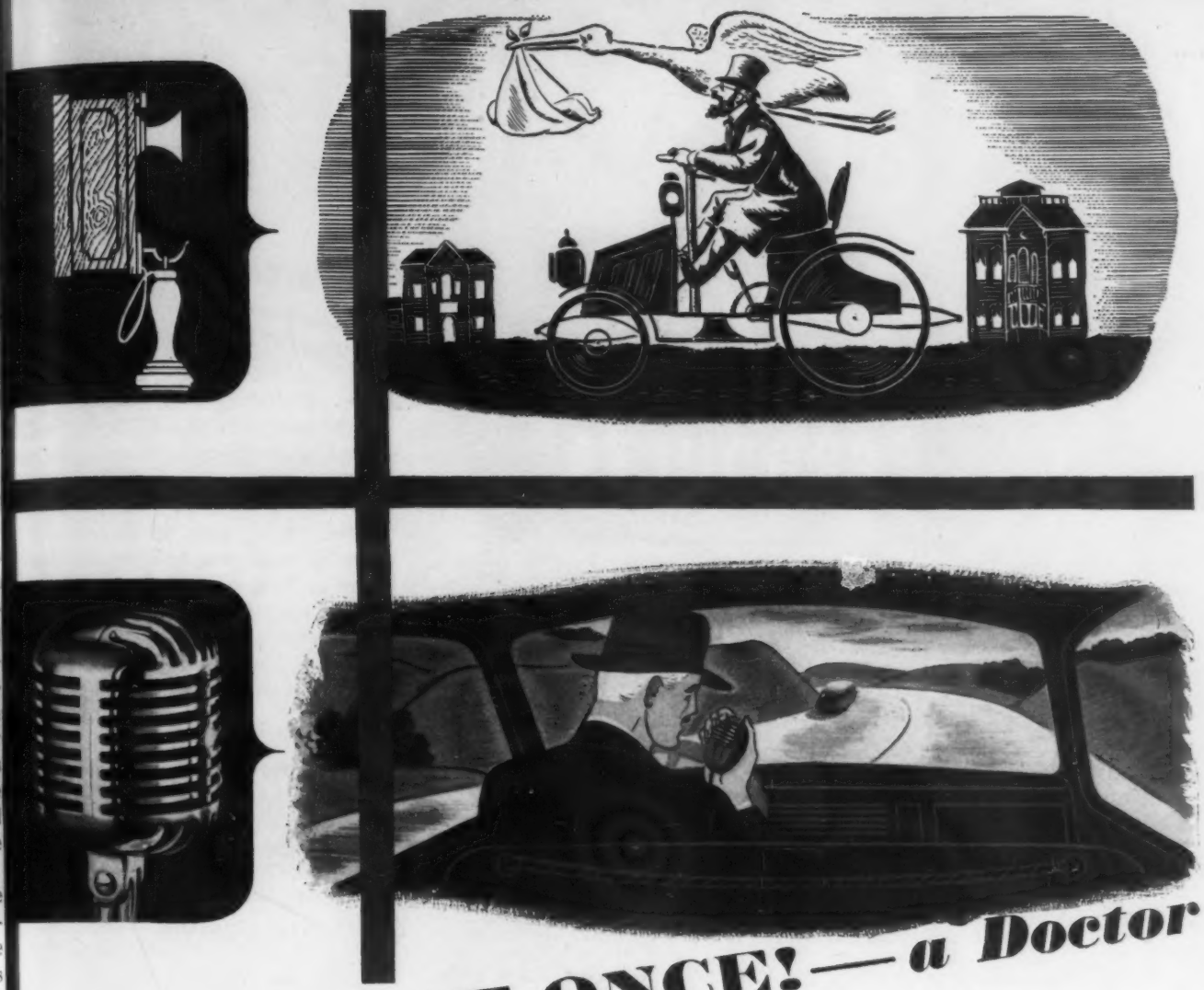
Other weak-current devices to be found are various types of amplifiers, synchroscopes, electronic wattmeters, no-voltage indicators and cable fault and pipe locators. Even the common portable cathode-ray oscilloscope is now finding much use in power system practice. There are also numerous electronic relays such as time delay circuits, sensitive and polarized relays and no voltage alarms.

Another branch of applications which reaches into the medium and heavy power devices is the use of rectifiers for obtaining high d-c voltages for testing purposes. Both the high vacuum diodes and controlled gas-filled and mercury tubes are used for this work. The high d-c voltages are needed for cable and insulation testing, smoke elimination in stacks, and in various laboratory tests. The protecting rubber goods which are used by linemen while working on "hot" lines are tested with a d-c voltage supplied by diode rectifiers.

At present the electronic voltage regulator is perhaps the most popular medium power device. These regulators use small thyratrons as the primary controlling element. The thyratron circuit works into the field of the rotary exciter or into an electronic exciter. In either case the controlled exciter voltage in turn determines the voltage of the large alternator. The index voltage upon which the thyratrons act is obtained through a step-down transformer fed from the output of the alternator.

Grid controlled rectifiers are now used for charging power station batteries. The electronic circuits govern the charge rate so that the correct tapered charge is applied to the battery.

In the high power electronics field in power system work the outstanding developments have been the controlled rectifiers and frequency changers now used for several different purposes. One very popular use of the rectifier alone is for supplying power for d-c traction systems. Another common use of this equipment is the supplying of direct current for electrolytic processes for the production and refining of alumi-



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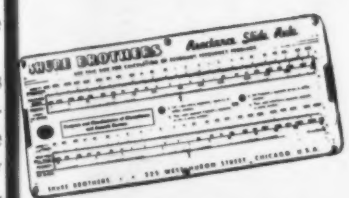

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num, copper, zinc, etc. Many thousands of kilowatts of direct current are developed by controlled rectifiers for production of metals.

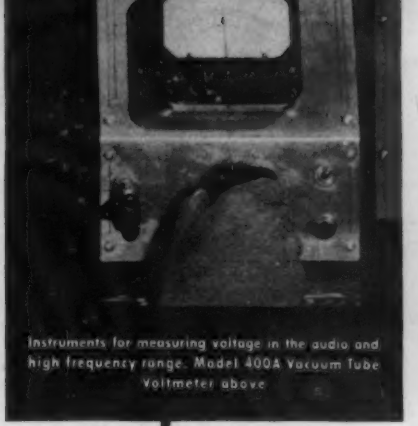
Electronic frequency changers handling 5000 kw continuously are in use at the present time. This equipment is used for supplying power for traction purposes at a frequency other than the available power frequency. The electronic type of changer offers several advantages over the rotary type.

Chief among the advantages of the rectifier over rotary machines is the ability of the electronic equipment to accept momentary overloads and even short circuits without damage. A load which varies rapidly and over great values is easily handled by electronic equipment. Rotary equipment under the same conditions may flash over at the commutator or require load shifting. The factor of overall efficiency is a little in favor of the electronic equipment.

Much thought has been given the idea of using high voltage d-c power transmission lines instead of the present a-c type. This would eliminate the line drop due to inductance and also the effects of line capacity. The voltage could be raised to a value higher than that now used for a-c work before corona losses occurred. Dielectric losses of the transmission line could be greatly reduced. With this system the generation and distribution of the power would be in the form of alternating current as at present. Grid controlled mercury arc rectifiers would change the a-c power of the correct voltage to direct current for transmission. At the distribution end of the line, electronic inverters would change the power back to alternating current of the desired frequency. Constant-current as well as constant-voltage systems have been designed for the d-c operation. This is another example of the adaptability of the grid controlled mercury arc tube.

The future of power system electronics appears to be as unlimited as it is in the related applications. Upon the cessation of our world conflict, such electronic development will receive more attention than ever before. The science of electronics is destined to become one of the most important aids to mankind.

...ments for measuring frequency including secondary frequency standard and electronic frequency ... Model 500A Electronic Frequency Meter above



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Post-War Radio

(*Continued from page* 95)

employed in electronic devices which detect, count, sort, measure, control, and perform many other tasks with infinitely greater precision and skill than it is possible for a human to do.

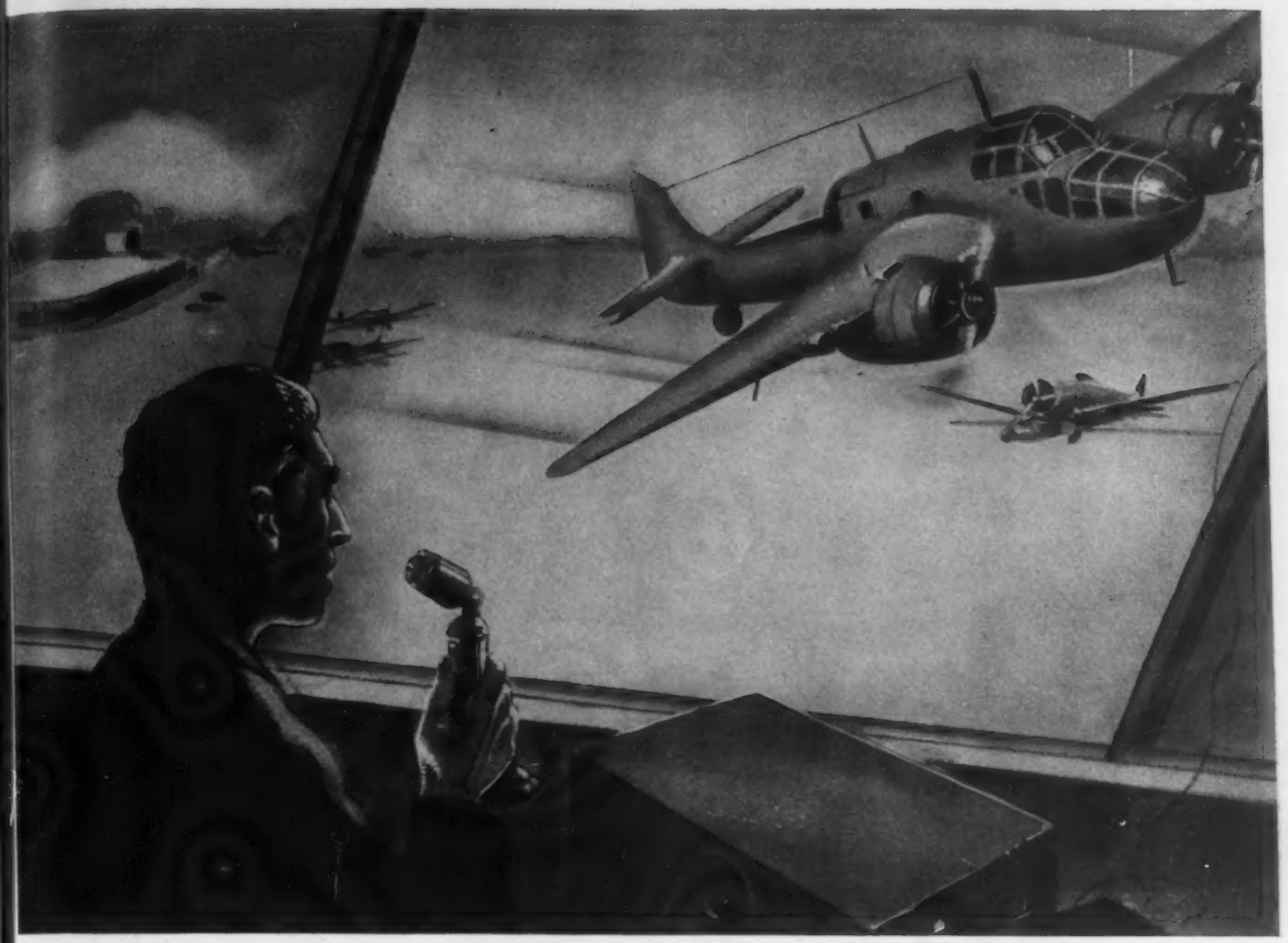
A most outstanding application of radio science to non-communication purposes is the electron microscope. This instrument, for many years a theoretical possibility and then a laboratory novelty, became a practical reality through research in electronic television.

Under the impetus of war, still another branch of radio is being brought forward with a rush. Radio Corporation of America engineers call it "radiothermics." It is a development which employs high-frequency radio waves to heat, glue, dry, case harden, anneal, rivet, weld, deactivate enzymes, and to perform other industrial and scientific processes that cannot be revealed now. Because high-frequency heating shortens production cycles, improves products, and enables processes once regarded as impractical, many industrial products and services of the future will be better and cheaper.

War also has stimulated the development and growth of the new field of industrial sound—an offspring of radio. Manufacturing plants, railroad yards, and airports in many parts of the country have installed comprehensive systems of sound reproduction, which speed up communication and the handling of traffic to a degree thought impossible a few years ago. They also are used to play music for employees, who find that this new service relieves fatigue and breaks the monotony of repetitive tasks. Industrial sound will have an important role in the post-war world.

I doubt that any other industry holds the challenge represented by the future of radio-electronics. The electron, smallest known bit of matter, is assumed to be one of the basic building blocks from which the ninety-two stable chemical elements are formed.

The industry accepts the challenge of the future; for radio is not simply an agency of communication. It is a gateway to progress.



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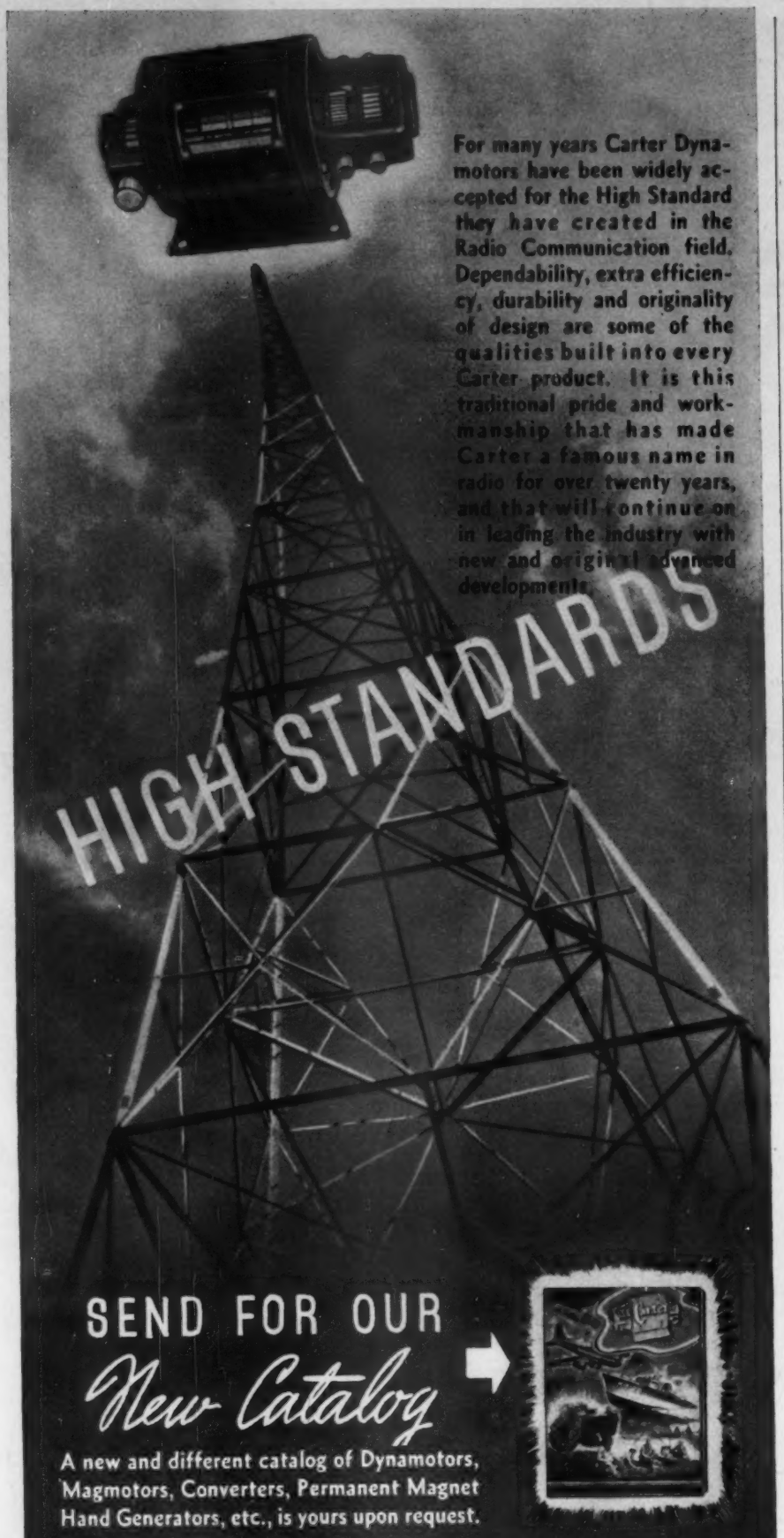
Electro-Voice MICROPHONES

ELECTRO-VOICE MANUFACTURING CO., INC. 1239 SOUTH BEND AVENUE, SOUTH BEND, INDIANA


For many years Carter Dynamotors have been widely accepted for the High Standard they have created in the Radio Communication field. Dependability, extra efficiency, durability and originality of design are some of the qualities built into every Carter product. It is this traditional pride and workmanship that has made Carter a famous name in radio for over twenty years, and that will continue on in leading the industry with new and original advanced developments.
HIGH STANDARDS
SEND FOR OUR
New Catalog
A new and different catalog of Dynamotors, Magmotors, Converters, Permanent Magnet Hand Generators, etc., is yours upon request.
Carter Motor Co.
Chicago, Illinois
1606 Milwaukee Ave. Carter, a well known name in radio for over twenty years. Cable: Genemotor

Television

(*Continued from page 99*)

the possibilities of theater television, as distinguished from television broadcasting for reception in the home. Equipment has been developed and demonstrated capable of projecting a satisfactory television picture on a 15 ft x 20 ft. screen in a motion picture theater. Connection of theaters in a metropolitan area to a central distributing point either by means of special radio circuits or specially equalized telephone circuits (this has been demonstrated to be feasible for short distances) may be readily accomplished. This would appear to offer a supplementary service for motion picture theaters.

So far, we have considered only the entertainment and educational possibilities of a television broadcast service. Obviously, any medium for the transmission of sight intelligence practically instantaneously from one point to another over great distances offers many other attractive possibilities and television may find a wide variety of special applications. Remote supervisory monitoring of industrial operations, demonstrations of techniques to large groups in classroom and laboratory teaching, remote identification of persons or objects, etc., suggest themselves at once as possible uses for this powerful new tool.

BIBLIOGRAPHY

Dunlap, Orrin, "The Future of Television," Harper, 1942.

Engstrom, E. W., Recent Developments in Television, New Horizons in Radio, *Annals of American Academy of Political and Social Science*, 213, p. 130, 1941.

Fink, D. G., "Principles of Television Engineering," McGraw-Hill Book Co., New York, 1940.

Goldmark, P. C., Color Television, ELECTRONICS, 13, No. 12, p. 26, (I.R.E., Rochester Convention) 1940.

Hanson, O. B., Experimental Studio Facilities for Television, *RCA Review*, 1, No. 4, p. 3, 1937.

Hanson, O. B., RCA-NBC Television Presents a Political Convention as First Long Distance Pickup, *RCA Review*, 5, No. 3, p. 267 1941.

Lohr, L., "Television Broadcasting," McGraw-Hill Book Co., New York, 1940.

Maloff, I. G. and Tolson, W. A., A Resume of the Technical Aspects of RCA Theater Television, *RCA Review*, 6, No. 1, p. 5, 1941.

Morris, R. M. and Shelby, R. E., Television Studio Design, *RCA Review*, 2, No. 1, p. 14, 1937.

Protzman, A. W., Television Studio Technique, *RCA Review*, 4, No. 4, p. 399, 1940.

Sarnoff, D., Probable Influences of Television on Society, *Jour. of Applied Physics*, 10, p. 426, 1939.

Sarnoff, D., Possible Social Effects of Television, New Horizons in Radio, *Annals of American Academy of Political and Social Science*, 213, p. 145, 1941.

Zworykin, V. K. and Morton, G. A. "Television," John Wiley and Sons, New York; Chapman and Hall, London, 1940.

Zworykin, V. K. and Shelby, R. E., Recent Television Developments, Physical Society, *Reports on Progress in Physics*, 8, p. 135, 1942.

EVERY ONE connected with the electronics industry can be proud that television is destined to be the big new industry of the post-war years. Business leaders and economists expect it to rival the growth of the automobile industry after the last war. It should help America "take up the slack" when Peace comes – enlist piled-up savings – make thousands of new jobs.

Farnsworth, pioneer and natural leader in television manufacture, is already enlarging that opportunity. Our advertising, right now, is telling America about the television to come – when the war is finally won.

Farnsworth production, today, goes entirely to the armed forces . . . fine precision equipment that will help United Nations win. When the war job is done, we'll be ready to supply the most advanced and most complete studio and station television equipment – the fruit of 16 years of research and invention in this field.

Television has always been Farnsworth's primary interest. And for the precision manufacture necessary, we have the plant and people who have built the superb Capehart Phonograph-Radio.

Farnsworth research made electronic television a reality . . . Farnsworth equipment will bring it —at its best—to America.

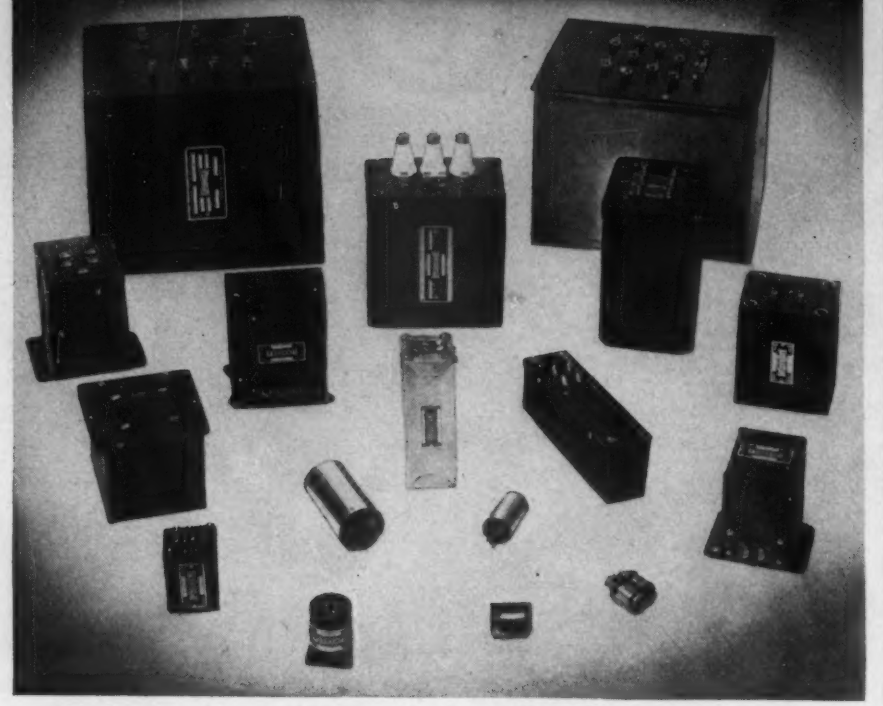
• PREPARING THE COUNTRY for television is the job of Farnsworth advertising. Read the current advertisement in March 22 *Time*, March 27 *New Yorker*, March 29 *Life*, April 3 *Collier's*, and April 5 *Newsweek*.

FARNSWORTH TELEVISION

• Farnsworth Television & Radio Corporation, Fort Wayne, Indiana. Manufacturers of Television and Radio Transmitters and Receivers; Aircraft Warning Equipment; the Farnsworth Dissector Tube; the Capehart, the Capehart-Panamuse and the Farnsworth Phonograph-Radios.

Different in Size-but

IDENTICAL IN QUALITY



For 50 years-Ferranti

has been preparing for TODAY

● **Behind us are the long years during which we built up our experience in making quality transformers and established our prestige in the field.**

Little did we realize what that would mean TODAY — how vitally it would help us meet the specifications of the Army, Navy, and Signal Corps.

To that priceless background of experience we have now added expanded manufacturing facilities. NOW we are fully prepared to produce Ferranti quality transformers — in larger quantities — at lower prices for a premium product.

Rush Deliveries — plus QUALITY at competitive prices.

Let us quote on your transformer requirements for radio, electrical, aircraft and electronic equipment and instruments.

Standard or special transformers. Rush us your specifications. *Phone, wire or write immediately.*

FERRANTI ELECTRIC, INC.
R. C. A. BLDG., NEW YORK, N. Y.

Military

(*Continued from page* 102)

are permanently installed in vehicles and obtain power from the vehicular electrical system. Others are portable, low-power transmitters and receivers which can be carried like suitcases and are operated from batteries. Auxiliary equipment makes it possible to install these portables in vehicles and operate them off the vehicular electrical system.

Messages may be sent either by radiotelegraph or radiotelephone. Special abbreviations are used in either case to convey the information which an observer, either at a forward vantage point or in the air, is in a position to get through to the fire control station. The Field Artillery radio sets provide communication for purposes of reconnaissance, direction of fire, and warning against impending attacks of enemy aircraft or tanks. One feature of these sets is remote control, enabling an operator to put a set in a physical location which provides for good transmission while he personally can work from a position with less exposure to enemy fire.

Considerable attention has been paid to the portable radio set carried by one man. The walkie-talkie, carried on a man's back, has already become familiar to all Americans. In the field of combat, it has already performed admirably in front-line reconnaissance and artillery observation. Better and more compact portable radios are under continual development. One of them is the tiny transreceiver which a man can hold in one hand while listening or talking. It is known as the "handie-talkie," although some troops like to call it the "cracker-box radio" because its size and shape resemble the common retail biscuit box.

Radio, Vital to Aerial Combat

Aerial warfare has provided a huge and diverse field for the application of radio. Communication itself is only one of many ways in which radio is used in aerial war. Radio plays a major role in helping the navigator plot his course in flying in a definite direction with or without the aid of a radio beam.

TO ENGINEERS FROM AN ENGINEERING MINDED COMPANY

AMP

AMP SUPPLIES TO THE ELECTRONIC INDUSTRY SUCH OUTSTANDING DEVELOPMENTS AS DIAMOND GRIP SOLDERLESS INSULATION SUPPORT TERMINALS WITH PRECISION HAND AND POWER INSTALLATION TOOLS PLUS A MULTITUDE OF OTHER SOLDERLESS WIRING DEVICES SPECIFICALLY DESIGNED FOR ELECTRONICS

Because of the dramatic impact of the results of developments in the electronic field and of the swift progress made in this field, it apparently is possible even for engineers to overlook the importance of changing practices and conceptions in the smaller components that go into development of electronic products.

AMP Diamond Grip Insulation Support Solderless Terminals and AMP Precision Hand Tools and Power Tools have introduced new concepts of the economics and engineering of applying millions of perfect terminals to the ends of millions of wires.

AMP Diamond Grip Insulation Support Solderless Terminals, lighter in weight, shorter in length, and accommodating in one terminal, wire sizes from 16-22 with assured visual inspection, are definite steps forward in engineering design.

AMP Diamond Grip Insulation Support Solderless Terminals are used in many critical applications in a multiplicity of electrical circuits including low voltage and high frequency. They have performed in the exacting conditions of war in gun control, aircraft, communications, radio, electronics and many other electrical fields.

The AMP Solderless Wiring System saves production time and assures uniformity of application by unskilled workers without the requirement of a pre-training period. Every connection applied under the AMP Solderless Wiring System is exactly like the one before.

AIRCRAFT-MARINE PRODUCTS, INC.

DEPT. B, 286 N. BROAD ST., ELIZABETH, N. J. Telephone: Elizabeth 2-6450

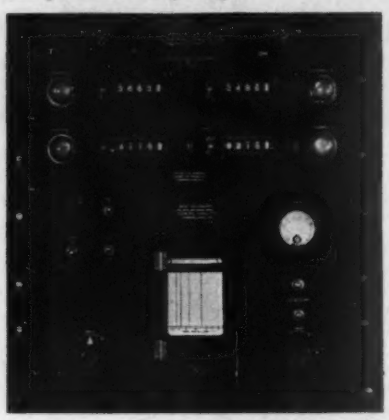
Tests made by unbiased, non-commercial laboratories show that AMP Diamond Grip Terminals show no significant change in resistance of the terminal even under the severest operating conditions. The tests included a multiplicity of circuits, variations in current, voltage, temperatures and corrosion. ***Detailed test data will be sent you on request.***

AIRCRAFT-MARINE PRODUCTS INC
AMP
SOLDERLESS WIRING DEVICES

"PRECISION ENGINEERING APPLIED TO THE END OF A WIRE"

The stroboscopic clock is for comparison of integrated oscillator frequency with radio time signals. The hand on the dial at the left indicates seconds; the two hands at the right indicate the tenths and thousandths of seconds. The received time signal flashes a stroboscopic lamp, which arrests the motion of the tenth-and thousandths-second hands once each second. The precision of reading is about 0.0002 second, which is equivalent to approximately two parts in one billion for a twenty-four-hour interval. Variations in radio-time-signal transmission, of course, make it impossible to utilize this precision completely.

THE MASTER STANDARD of FREQUENCY



Note the recording panels which show the beats between pairs of oscillators. The deviation from a vertical line is a measure of the variation in frequency of one oscillator with respect to the other, as indicated by the scale at the bottom of the chart. The precision of reading can be increased or decreased if desired. Beats are recorded between each of four oscillators and a common reference oscillator. If all beat records show identical deviations, the reference oscillator is drifting, while if only one line deviates, the drift is in the oscillator being measured.

Above the recorder are counters which indicate the time in seconds for a predetermined number of beats.

Nearly twenty years ago, the General Radio Company started a program of research and development in the field of frequency standardization, which has produced many general-purpose and specialized frequency measuring instruments for the world's civil and military communication systems.

The center of this research program is the master primary standard of frequency shown here, which supplies standard frequencies for the calibration of General Radio instruments and for measurements in the General Radio laboratories. Consisting of five quartz-crystal-controlled oscillators, with means for timing and intercomparing their frequencies, this standard is far more accurate than present-day commercial requirements. In addition to the frequency standard itself, the racks shown in the photograph include experimental equipment in which new circuits and methods are proved before their incorporation into commercial instruments.

To implement the production of military radio equipment, General Radio frequency measuring instruments are now more important than ever before. Their continued reliability and accuracy are assured by this master standard and the unceasing research program associated with it.

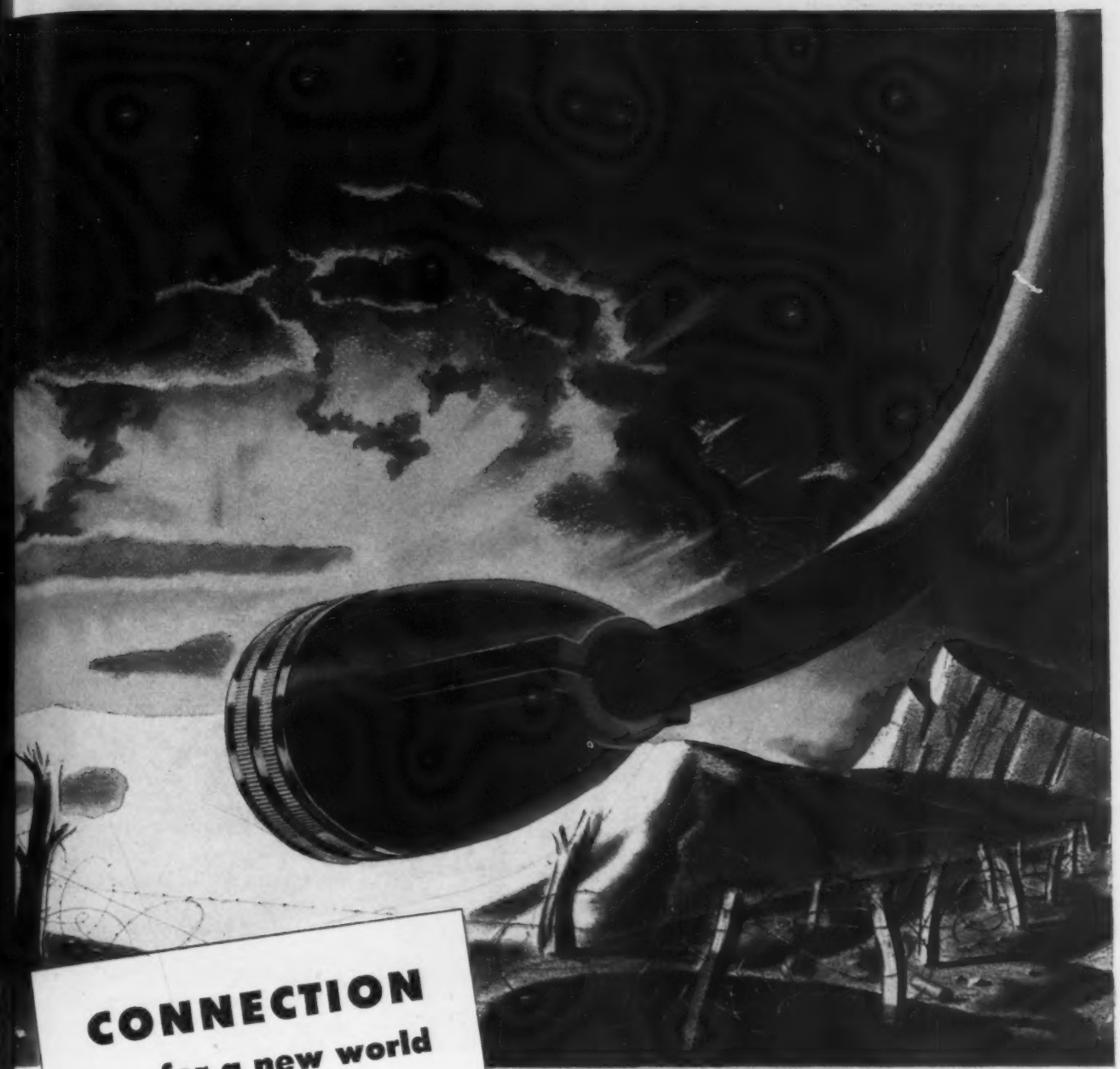
GENERAL RADIO COMPANY
Cambridge, Massachusetts

Radio altimeters tell the pilot ho high he is over the nearest terra obstacles, a tremendous improve ment over the pressure type alt meters which indicated altitud above sea level, and even then onl after further correction was mad in accordance with the barometri pressure variations due to weathe conditions at the moment. Radi serves in bringing pilots back t their home base and in guidin pilots to a blind landing under co ditions of "ceiling zero." Radi also serves in a very remarkabl way in the secret devices used fo detecting and locating enemy craf

CONTROL—Wire communications as wel as radio communications play an importan part in war. Here a gunnery Sergeant i shown receiving azimuth and elevatio from a range-finding crew by telephon

In preparing for any aerial unde taking, a knowledge of the win and other meteorological condition at various altitudes is of the utmos importance. For this purpose, th Signal Corps has applied radio i the form of tiny automatical operating transmitters carried b balloons to the upper layers of th atmosphere and sending signals t the ground to provide a continuou record of temperature and humidit at successively increasing altitude

Radio direction finders play a important part in locating enem transmitters. Special signal radi intelligence personnel are assigne to monitor the enemy wavelength and keep a record of their transmis sions. In our own operations,



CONNECTION
....for a new world

Cannon Connectors, used wherever electrical connections must be made quickly, safely and securely, now serve as the means for connecting the many electrical circuits used in the control and operation of the weapons of war.

When the war is won, these same Cannon Connectors will again be available for peacetime consumers on a host of electrical devices not even dreamed of now. And, having passed the rigorous tests of war, they will assure even a higher degree of dependable performance under the less strenuous demands of peaceful living.

FOR VICTORY BUY WAR BONDS AND STAMPS

CANNON ELECTRIC

Cannon Electric Development Company, Los Angeles, California

Canadian Factory and Engineering Office: Cannon Electric Company, Limited, Toronto, Canada

Representatives in principal cities — consult your local telephone book

Before the Big Battle Is Won

WHEN our battle wagons sight the enemy—victory depends largely on the fitness and accuracy of every part used in the construction of these ships.

Included in the vital equipment are the gun-firing transformers which provide the current of selected voltage specified for the gun-firing job. Here the experienced craftsmanship in transformer design and construction at Jefferson Electric insures the unfaltering service demanded. Built to withstand sea air and moisture, these transformers ride the waves with the Navy.

Jefferson Electric products are playing an important part in War activities;—Transformers for communication systems,—for factory and airport lighting systems,—Ballasts for fluorescent lamps,—Fuses for protecting electrical equipment and systems on board ship and in plants where combat equipment is made. JEFFERSON ELECTRIC COMPANY, Bellwood (Suburb of Chicago), Ill. Canadian Factory: 60-64 Osler Avenue, West Toronto, Ontario.

JEFFERSON ELECTRIC

TRANSFORMERS

course, discretion is observed to p vent the enemy from hearing much. However, there is one type radio transmission to which enemy—both his troops and people at home—are invited to lis These are the broadcasts which p sent factual news and the vie point of the United Nations to people of the Axis nations and people of nations subjugated them. The Signal Corps is charg among other things, with providi these powerful transmitters, though the decision as to what p gram shall be carried on them made by other agencies. A nota example was the transportation a powerful station to North Afri which set up business on a wa length adjacent to the regul Morocco station and played an i portant part in putting the Americ story before the French populati during the confused days that f lowed the initial landing. Techni cians of the United States Sign Corps are always prepared to ta over radio stations in occupied are and adapt them to serve the militar and political ends of the United N tions.

The Echelon Concept Applied to Communications

In the organization of militar communications, the concept "echelons" is very important. A echelon is a level of organizatio Suppose that a national radio ne work were so arranged that eac local station, instead of broadcastin its program directly to the listener sent it out to a limited number o sub-stations, and then, in turn, eac sub-station covered a number of low power transmitters located in eac city block. We would then have series of levels through which th broadcast information finally reache the public. Of course, such a sys tem would be unnecessarily elab orate for the broadcasting of publi information. Such a system, how ever, must be used in military opera tions. Reports and orders are no meant for all ears. They ar designed for the exclusive use o particular listeners.

In military communications, the responsibility for transmission o information always devolves upon the higher echelon. In other words, the commanding general of an over-seas theater of operations is respon-sible for the communications lines

Communications and other radio equipment made by Wilcox are at work to help carry on flight control safely under the increased strain of wartime activity. Present Wilcox manufacturing is devoted exclusively to the Government's needs to coordinate fighting forces on land, sea and in the air with vital communications. Until peace is won, the sign on our door reads, "Uncle Sam comes first."

Communication Receivers
Aircraft Radio
Broadcast Equipment
Control Apparatus
Transmitting Equipment

WILCOX ELECTRIC COMPANY

Quality Manufacturing of Radio Equipment

14th & Chestnut Kansas City, Missouri

THE "MALLARD" — one of Cinaudagraph Speakers' achievements—designed to meet War standards. The finished Mallard is an unenclosed, moisture-impervious speaker — some have been tested under water and recommended wherever outdoor installations are required.

This is typical of the way Cinaudagraph Speaker Engineers keep taking all problems in stride—the reason why so many Cinaudagraph Speakers are handling their part of the Victory Load.

Cinaudagraph Speakers, Inc.

3911 S. Michigan Ave., Chicago

"No Finer Speaker Made in all the World"

by which his orders are transmitt to the separate forces under h command and by which informati and reports are transmitted fr them to him. His subordinate, s the commanding general of a cor is responsible for communicatio down to the headquarters of t divisions under his command. H carries out this responsibili through the use of several sign battalions and companies which sp cialize either in radio or wire co munication. In turn, the comman ing general of each division responsible for the communicatio to the regiments and other co ponents of that division. These a carried out by a special division si nal company whose commandin officer is the division signal office a lieutenant colonel. The divisio signal company includes a hea quarters platoon which runs th administrative functions of the co pany, a message center platoon, wire platoon, and a radio platoo the latter being divided into sectio for radio communications and radi intelligence. In the higher echelon such as the corps, there will b entire signal companies devoted e clusively to radio repair or to radi intelligence or to some similar fun tion.

Radio Maintenance also Operates in Echelons

The maintenance of Army Signa Corps radio equipment is also ac complished in a series of echelon The first echelon is constituted b the using operator. The man wh operates a walkie-talkie or a fiel radio set is not necessarily skille in the mechanics or theory of radi repair. However, he has available to him as standard equipment a cer tain number of spare parts such a tubes and extra batteries. When a battery runs down or a tube burn out, it is his prerogative to replac it with a fresh one. Or if a wir gets loose, he may reconnect it t the terminal. However, anything beyond that normally would be sen back to the division signal company for repair. This company's repair section has testing equipment and men skilled in the knowledge and techniques necessary for utilizing that equipment to the best advantage. If a set can be put back into shape by additional replacements or by ordinary rewiring, this is done.

Hytron

DEDICATES the PRESENT to PRESERVATION of the FUTURE

HYTRON'S SOLE PURPOSE for the duration is to maintain an always-increasing flow of tubes into the radio and electronic equipment which is playing a vital part in winning this Radio War. It is our firm conviction that the torch of Liberty which Hytron is helping to keep burning will light the way to the unconditional surrender of our enemies and to an electronic age which will amaze a freed world.

HYTRON CORP., Salem and Newburyport, Mass.

. . . Manufacturers of Radio Tubes Since 1921 . . .

UTAH-CARTER PARTS
TRANSFORMERS · SPEAKERS VIBRATORS

UTAH TRANSFORMERS

Utah Transformers are fully guaranteed. They have a non-corrosive, protective film of cellulose acetate which provides absolute insulation—prevents breaking down even under extremely high humidity and severe atmospheric conditions. The high safety factor of their insulation is proved by the extra hours of satisfactory performance.

No matter what your requirements are in broadcast, communication, neon or smaller capacity power transformers, Utah is ready to serve you. Write for full details on Utah's complete line of transformers.

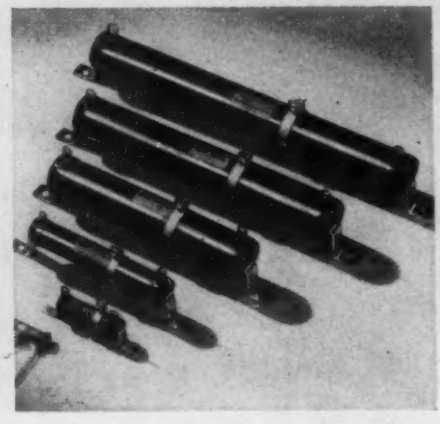
UTAH WIREWOUND CONTROLS

Rheostats, Potentiometers, Attenuators. High quality resistant wire evenly wound on a substantial core is clamped tightly to the control housing, resulting in a rugged and dependable variable resistor. Five sizes—3, 4, 9, 15 and 25 watts are available in the Rheostats and Potentiometers; resistant elements can be wound linear or to special resistant-curve tapers.

VITREOUS ENAMELED RESISTORS

Utah-Carter Vitreous Enameled Resistors represent over a decade of experience, starting with the first 10- and 20-watt types made by the Carter Radio Company, and progressively improved by engineers and technicians of the present company.

A minimum of two separately fired coats of Vitreous Enamel forms a hard, glassy surface—adhering permanently to the porcelain tube core, resistance wire and terminals. Resistors 5- to 200-watts are available either as Fixed—Tapped—or Adjustable. Numerous styles of mounting hardware are available to meet your individual requirements.



PHONE JACKS AND PLUGS

The Utah-Carter "Imp" Jacks are popular because they combine compact size, highest quality and economical price; Unique, Patented design makes them the smallest Jack-fitting standard Phone Plugs. These many features added together have made Carter Imp Jacks famous Defense Items.

Phone Plugs, 2- and 3-conductor types, designed to meet your needs—whether it be application, size or shape.

Utah is manufacturing Phone Jacks and Plugs according to Signal Corps and Navy Specifications.

UTAH SPEAKERS

give you the benefit of the constant laboratory testing and research which result in sound improvement.

UTAH VIBRATORS

are precision made and delicately adjusted for long life, correct electrical balance, current output and freedom from noise.

WRITE FOR FULL DETAILS

UTAH RADIO PRODUCTS COMPANY
General Offices and Factory
837 ORLEANS STREET · CHICAGO, ILLINOIS

However, if the equipment has been badly smashed up or if it is of an extremely complex nature, it might be sent back to the third echelon which would be a signal repair company installed in a depot or at Army headquarters. Supporting these forward echelons, which are staffed by troops of the Signal Corps, are the rear echelons of repair in the continental United States. These are maintenance shops staffed by civilians in all the service commands. The final echelons are large and elaborate shops, also staffed by civilian mechanics, located in the larger Signal Corps depots such as the Philadelphia and Lexington Depots. If *they* can't salvage a set, it's junk.

Not only do electronic means speed the flow of information and orders on the battlefield, but they figure in the life of the soldier in the training camps. The films by which the new soldier is instructed in many of the fundamentals of Army life are provided with electronically recorded and amplified sound tracks. And electron tubes even serve to get the soldier out of bed in the morning—for the sleep-slaying sound of reveille no longer comes, in the up-to-date training camp, directly from the frost bitten but nevertheless human lips of a bugler, but from an impersonal phonograph record feeding into an electronically operated Public Address system.

• • •

TELEPHONE LINEMEN

An American peep and a trailer of the U. S. Army Signal Corps lays telephone wire through a path of heavy matted grass. As the wire unrolls it falls to the path behind the outfit. The grass is known as "kunai"

Here's how you can teach new employees to machine efficiently . . . . .

NATIONAL VULCANIZED FIBRE & PHENOLITE

This "National Inform-a-Sheet No. 5," shown above, contains easy-to-read, easy-to-understand data on how to machine National Vulcanized Fibre and Phenolite, laminated Bakelite practically and efficiently. The information is simply presented and illustrated so that new hands can be taught quickly the correct fabrication of these materials. You can save time and trouble and conserve material through using this technical bulletin. Ample quantities of the bulletin are available on request.

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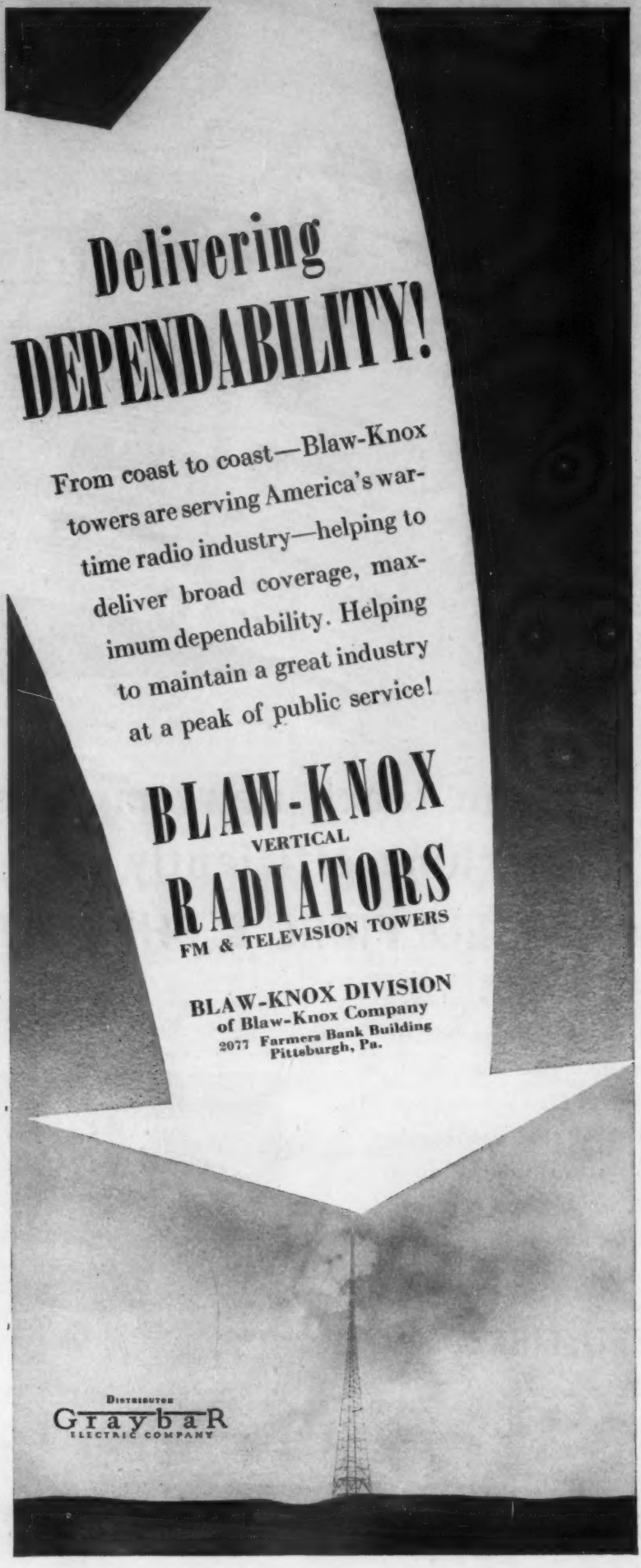


Aviation

(*Continued from page* 105)

facility consisted of a group of transmitters operating on a frequency of 75 megacycles. These transmitters are equipped with one of two types of antennas. One type of antenna produces a circular field pattern in the horizontal plane while the other gives an elliptical pattern. This marker facility is received on a separate radio receiver in the airplane and serves to light a lamp whenever the marker signal is received. The circular pattern is used to indicate the position of the terminal radio range station, while the elliptical pattern is used to mark the intersection of two radio range courses. The sensitivity of the receivers used for receiving the marker signal is adjusted to give an indication for any desired period of time, and remains fixed. Despite the operation of all marker transmitters on the same frequency, the range of these marker signals is so limited that there is no interference.

In addition to the markers just described, which indicate terminals and airway intersections, some are used to mark the outer approaches and boundaries of a landing field. These latter markers also operate on 75 megacycles but employ modulation distinctive from that employed by the other markers. In the airplane, the various audio frequencies are suitably filtered and illuminate white, amber, or blue lamps. Because they operate at high frequencies, these facilities are not troubled by static to any large degree. When the static has obliterated reception of the long-wave radio, these lamps in the cockpit still become illuminated and indicate the true location of a point on the ground.

Development of Instrument Landing

After an airplane has avigated two dimensions in safety it is still necessary to travel a third—*down*—before the trip is completed. The matter of instrument landing, possible only because of the electronic art, has had a long and interesting history. Instrument landing systems (means for landing under so-called "blind" conditions) were installed and tested by the National Bureau of Standards as early as 1931. Recently the Civil Aeronautics Admin-

METALS-COMPOSITIONS

CONTACTS

exactly the right type for your job!

Almost two decades have passed since Stackpole revolutionized circuit breaker and control equipment performance by producing, at the suggestion of Westinghouse engineers, the first molded silver-graphite contact—one which enabled a 50 ampere continuous-rated unit to handle 5,000 amperes on a short circuit. Today, Stackpole offers a complete line for almost any application—from the various silver compositions to dozens of special alloys. Equally important is the wealth of contact engineering experience which not only helps select the *right* contacts for your job but helps design your equipment to utilize them for utmost service and dependability.

OTHER STACKPOLE PRODUCTS

for Electronic, Electric and Industrial Needs

Whatever your need in molded carbon, metal, or composition products—from brushes to brake lining—it pays to try Stackpole *first*. Long years of engineering leadership assure utmost reliability for the following wide range of products:

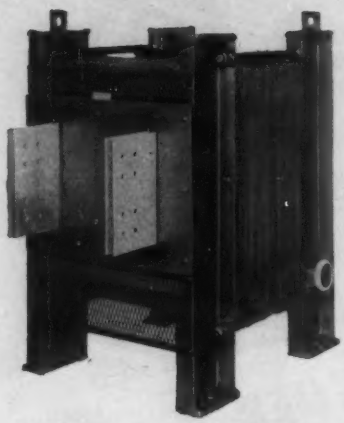
BRUSHES FOR ALL ROTATING EQUIPMENT
(All carbon, graphite, metal and composition types)
BEARINGS
ELECTRODES **ANODES**
BRAZING BLOCKS
WELDING RODS, ELECTRODES and PLATES
POWER TUBE ANODES **BRAKE LINING**
PACKING, PISTON and SEAL RINGS
RHEOSTAT PLATES and DISCS
FLASHLIGHT BATTERY CARBONS
. . . and various specialties

Stackpole representatives are located in principal cities to serve you.

it's STACKPOLE

STACKPOLE CARBON COMPANY, ST. MARYS, PA.

Write your own ticket on transformer specifications-with Newark TRANSFORMERS



This was a tough one

—but not for Newark. A dry type transformer to get 10,000 amps., low voltage, for a special furnace. Newark is at home on jobs like this.

We can build them to fit—with twenty years of "know how" behind them. Dry type transformers in standard or special types using components of proven correctness and quality, in capacities from 1 to 150 kva. Early delivery dates may surprise you, too. Newark transformers have made as fine a record in production as they do in performance. Tell us your conditions — phone, wire or write. Bulletins on request.

Do you need SUBCONTRACT help?

Call upon the facilities of our Subcontract Division, established long before Pearl Harbor. Floor space, machines, men available. Also the cooperation of a skilled engineering staff. Our record on this work demonstrates exceptional ingenuity in dealing with a wide variety of difficult manufacturing problems. Production time schedules always met, frequently bettered. Depend upon our production drive to get things *done*, and upon our 20 years of experience to get them done *right*. Our facilities may be just what you need. Phone or wire

SUBCONTRACT DIVISION
(Phone, Bigelow 3-3577)

Newark TRANSFORMER CO.

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NEWARK, NEW JERSEY

TRANSFORMERS FOR ALL PURPOSES

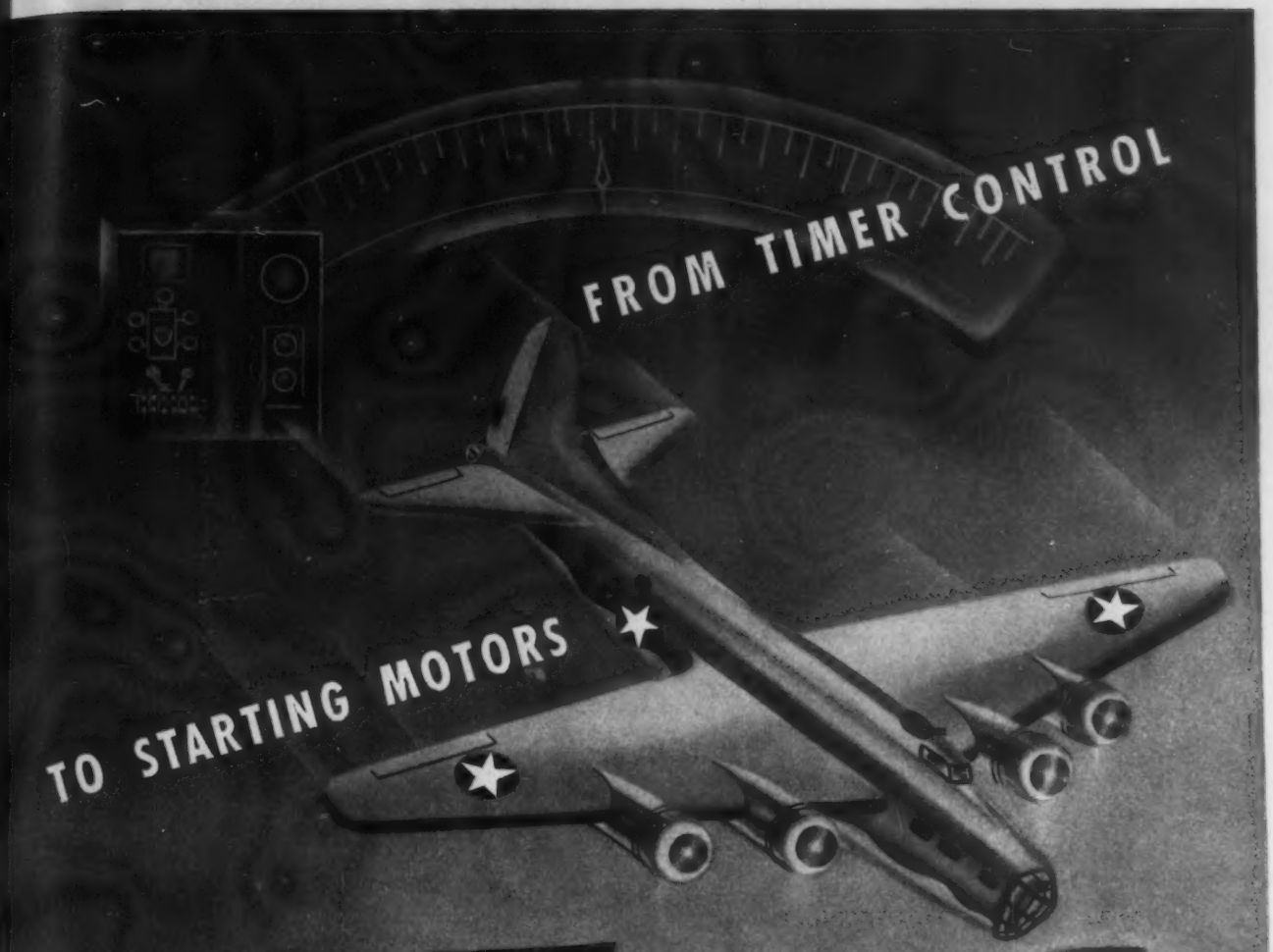
istration announced the installation of the first steps in a Government instrument landing net intended to cover all major cities in the United States. The reason for the long period that has elapsed between the time of initial installation and commercial use was due to continued development in order to arrive at a satisfactory system. Since an instrument landing is the most difficult maneuver that an airplane executes, it was wise that the problem should have been treated with extreme caution.

The system now being installed is not far different in principle from the initial system of the Bureau of Standards; however, the instrumentation, as might be expected, has been greatly improved. The system consists of a miniature radio range similar to the ultrahigh-frequency range previously described, the markers of the type already discussed, and a third element known as the glide path. The radio ranges mark the runways and the approaches to them, the markers indicate progress toward the point of contact, while the new element indicates the position of the airplane with respect to a fixed and predetermined glide path. The glide path is indicated on an instrument with a horizontal pointer. Displacement of the needle from the center of the meter indicates that the airplane is above or below the desired landing path. A second needle on the face of the same

• • •

BLIND REPAIRMAN

Byron H. Webb, blind graduate of DePaul University, teaches Army Signal Corps members to repair radios. His fingers and keen hearing take the place of eyes and he uses ear-phones instead of the usual meters. In the photo he is showing Corp. Peter Miller (left) and Pvt. Edward Mosebach how to estimate voltage by the strength of auditory signals and to locate any defects in the wiring



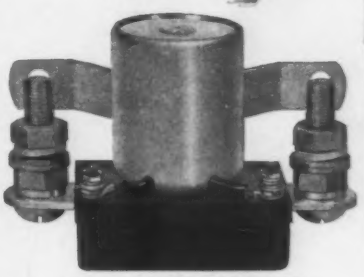
RELAYS by GUARDIAN

Giving split-second accuracy to timing devices, "Relays by Guardian" are widely used in Thermatrols . . . Pyrometers . . . and dozens of other electrically operated instruments. But the war has brought thousands of new uses, calling for greater precision than ever . . . for firing and timing guns . . . for controlling battle radios . . . for swiveling "Fortress" turrets . . . for doing hundreds of war control jobs. One of the newest Guardian developments is . . .

B-8 . . . NEW LIGHTWEIGHT SOLENOID CONTACTOR

Built to U. S. Army Air Force specifications for aircraft engine starting motors. With variations in mounting brackets and terminals the B-8 will meet intermittent duty specifications of the B-4, B-6A and B-7A Contactors. Contacts are rated at 200 amperes and will not chatter on voltage drops caused by starting current surges. "Pull-in" voltage is 6 volts as compared to 18 volts on contactors with which the B-8 is interchangeable.

Write for B-8 Bulletin for further information. Or for SC-25 Bulletin for technical data on continuous duty contactors.



B-8 SOLENOID CONTACTOR
On ten thousand units this new design saves over three tons of critical materials.

GUARDIAN ELECTRIC

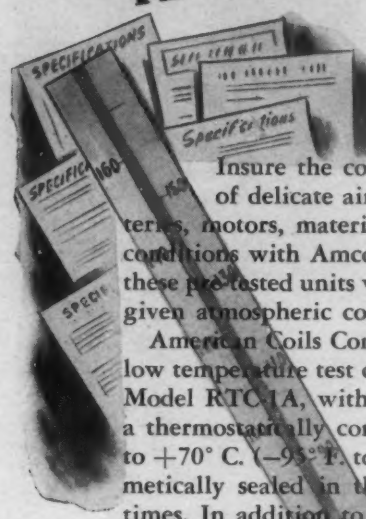
1625-C WEST WALNUT STREET — CHICAGO, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN WAR INDUSTRY

Compliance

WITH HIGH AND LOW TEMPERATURE SPECIFICATIONS

Insured



Insure the compliance with temperature specifications of delicate aircraft instruments, electronic devices, batteries, motors, materials and other products under actual war conditions with Amcoil Test Chambers. Know in advance that these pre-tested units will react according to specifications under given atmospheric conditions.

American Coils Company builds a complete line of high and low temperature test chambers that will provide that insurance. Model RTC-1A, with a usable interior of 25.7 cubic feet, has a thermostatically controlled temperature range of from −70° to +70° C. (−95° F. to +160° F.). Five thicknesses of glass, hermetically sealed in the door, provide perfect visibility at all times. In addition to the RTC-1A there is a complete line of temperature test chambers, large and small, with either mechanical or dry ice refrigeration.

FOR HUMIDITY TESTING, Amcoil manufactures an individual unit which can be easily attached to their temperature test chambers.

FOR ALTITUDE TESTING, special chambers are available.

Let Amcoil Engineers advise you of the type of equipment best suited to insure the compliance with atmospheric specifications.

MODEL — RTC-1 Mechanical Refrigeration; Temperature range: −55° C. to +70° C. Usable interior 28.7 cu. ft.

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3715

instrument moves to the right or left indicating the position of the airplane with respect to the center of the runway. The pilot flies his airplane so that the needles of this instrument are crossed in the center.

The instrument landing system indication can be obtained in the airplane by the addition of a receiver operating on 93 megacycles. With this receiver the glide path indications are obtained. The same receiver used to receive the ultrahigh-frequency ranges also receives the runway indication, and the same marker receiver used to indicate the airway markers receives the instrument landing marker indications.

Electronic Altimeters are Next Step

In 1938 the first successful radio altimeter was announced. This device gave directly the distance from the airplane to the ground. This unit was considered to be rather heavy and the power consumption was large for the power systems used in the airplanes of 1938; however, further development was conducted up to the time of the war. The adoption of such a device will probably be given favorable consideration by the airlines when conditions become normal.

The radio altimeter has many uses. While it does not indicate the presence of an object directly ahead, it does indicate a decrease in altitude such as would be experienced when foothills of many ranges are approached. One of its most important uses will be as a check on the instrument landing systems. With this device, the pilot making a descent will know how soon he may expect to contact the ground.

The above outlined navigational and avigational systems are made possible only because of the existence of electronics. It can be seen that while electron tubes were big aids to navigation, they were the very essence of avigation.

Many devices have been developed that will assure safe travel of the large air transports of the future. Installation of many of these, which had just begun, had to be stopped when the war broke out. It seems unfortunate that this should have been the case; however, the experience in electronics that will be gained during the period of the war may lead to developments that will offset the delay in installation.

PRECISION POWER TUBES FOR EVERY PURPOSE MADE BY UNITED

Skills in Electronics

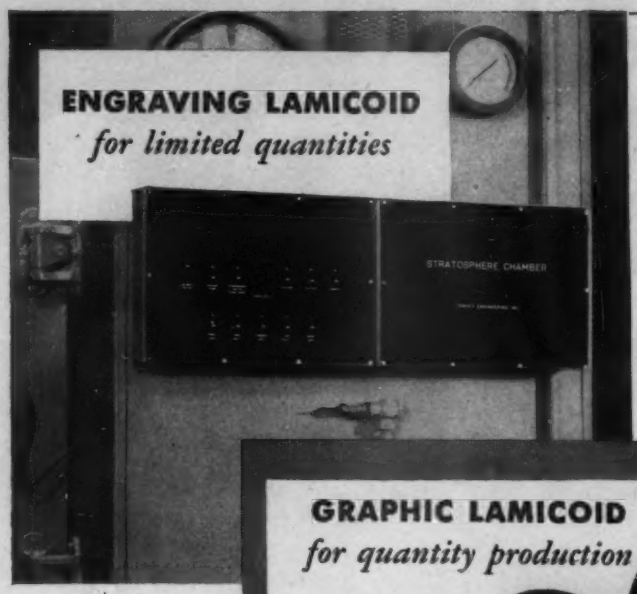
When the war ends, there will be a phenomenal expansion in the peace-time use of electronics. Today—while the war absorbs the tube output—try to fix in your mind this unique source for tubes which you will seek tomorrow:

Its name: UNITED. Its organization: a group of eminent engineers and technicians, uniting their highly specialized skills. Its product: power tubes, unsurpassed in precision, for every electronic requirement including radio communication, physiotherapy and industrial control. Its standard: power tubes that consistently attain the highest record in every test of performance. Remember the name "United."

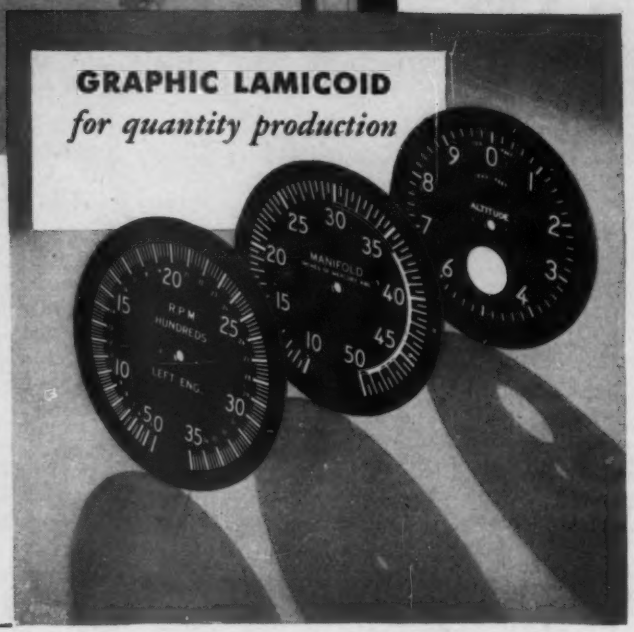
UNITED ELECTRONICS COMPANY

NEWARK, NEW JERSEY

2 WAYS to get clean-cut lettering and a permanent finish FOR DIALS AND PANELS



A "sandwich" type plastic-resin sheet in which lettering, calibrations and designs are engraved through the lustrous surface exposing the contrasting core. Clean-cut and permanent, nothing to wear off. Available with either black or white surface and with opaque or translucent back, for rear illumination.



A tough plastic-resin sheet in which printed lettering, calibrations and designs, in black or color are permanently incorporated and cannot fade, be removed or erased. Opaque or Translucent for direct or rear illumination; and special finish (2-D) suitable for writing on with pencil or ink and erasing repeatedly without wear on the material.

LAMICOID is now used by countless manufacturers working on Army and Navy contracts. Find out whether Lamicoid can also save valuable metal and delivery time on your war work. Send the coupon below with samples or blueprints of the dials, panels and nameplates you need. We will quote prices and delivery promptly—without obligation.

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Quote prices on quantities of _____. This is NOT an order.

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Facsimile

(*Continued from page* 107)

tems in the frequency band above the highest telegraph channel. The telegraph industry looks to the concentric cable and other wide-band transmission mediums to provide the channels necessary for a more rapid expansion of long distance facsimile transmission in the future.

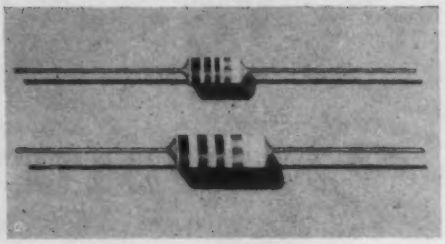
At the present time facsimile telegraphy is enjoying its greatest development in the field of local pickup and delivery. Here, where facsimile has exclusive use of the circuit, the possibilities are almost unlimited. Here not only has facsimile made it easier for the patron to telegraph, but it has reduced tremendously the time required for pickup and delivery which has always been a major factor in the handling of telegrams. Systems of this type in operation in New York, Chicago, Atlanta and San Francisco handled over 1,000,000 telegrams in 1942. Rapid expansion of such systems was in progress when wartime conditions forced temporary curtailment. Facsimile installations are now being restricted to those of military necessity.

Frequency modulation has not yet been employed extensively in facsimile transmission over wire lines. Its use is not likely to prove as advantageous as in radio transmission due to the greater stability of wire circuits, although tests have shown it to be of value in certain instances.

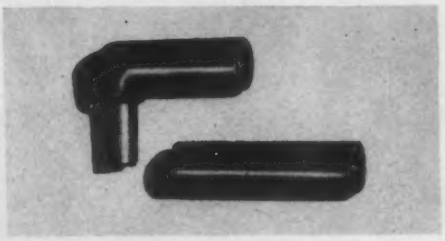
Facsimile is definitely making it easier to telegraph. It is not too difficult to visualize the eventual replacement of the branch telegraph offices by simple automatic facsimile machines installed in office buildings, bus, railroad and plane terminals, factories, apartment house lobbies, perhaps even in the corner drug or cigar store. Facsimile telegraphy will undoubtedly be among the new industries which will help keep the wheels of production turning when the world turns back to peaceful pursuits once again. Just as facsimile's rapid progress of the past decade must be credited largely to developments in the science of electronics, so to an even greater degree facsimile's hopes for the future are based on expectations of new developments in this field.

* Editor's Note. Although very simple facsimile systems have been developed for home use as adjuncts to the ordinary broadcast radio receiver, war has stopped work in this field. Since post-war facsimile for home use will undoubtedly be greatly different than pre-war systems, this phase of facsimile has not been covered in this symposium.

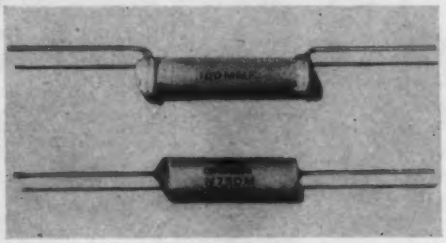
ERIE RESISTORS AND CONDENSERS



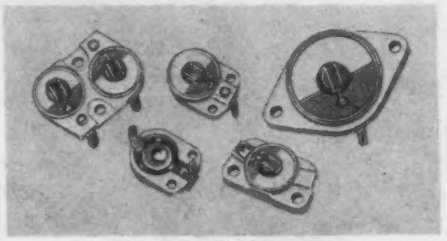
1 ERIE RESISTORS



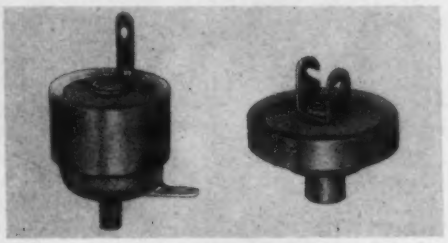
2 ERIE SUPPRESSORS



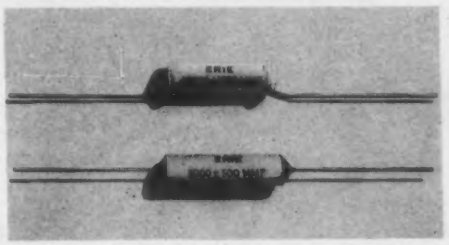
3 CERAMICONS



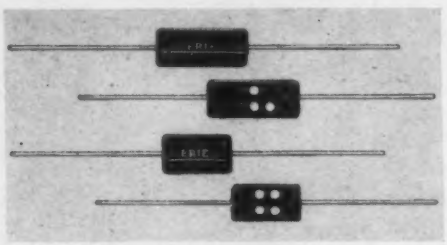
4 CERAMICON TRIMMERS



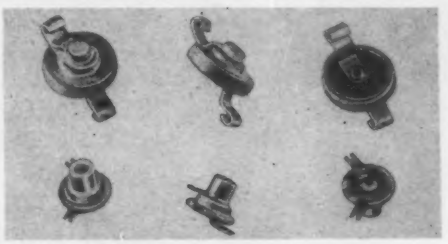
5 DISC CERAMICONS



6 HIGH DIELECTRIC CERAMIC CONDENSERS



7 ERIE SILVER MICAS



8 ERIE BUTTON MICAS

1 **ERIE RESISTORS**—Made in ½ and 1 watt insulated, 2 and 4 watt non-insulated styles in resistance values from a few ohms to 100 megohms.

2 **ERIE SUPPRESSORS**—Efficiently eliminate ignition interference in radio receivers. Type L-4 for spark plugs and S-5 for distributors approved by U. S. Signal Corps.

3 **ERIE CERAMICONS**—Tubular, silver-ceramic capacitors, available in 10 standard temperature coefficients from + 100 (P 100) to —750 (N750) parts/million /°C (P/M/°C). 1100 MMF maximum capacity in N750. Temperature coefficient tolerance ± 60 P/M/°C or ± 15%, whichever is greater.

4 **ERIE CERAMICON TRIMMERS**—Adjustable ceramic condensers, made in one double and three single styles. Temperature coefficients, zero, —300, and —500 parts/million/°C (± 100 P/M/°C). Capacity ranges between 1.5 to 7 MMF in NPO, and 10 to 110 MMF in N500 are available.

5 **ERIE DISC CERAMICONS**—Type 1770, rated 500 volts D. C., maximum capacity 850 MMF in NPO, 4,000 MMF in N750 temperature coefficient; Type 170, rated 1,000 volts D. C., maximum capacity 1,000 MMF in NPO and 4,000 MMF in N750 corresponding capacities at 1,500 volts, D. C., 375 MMF and 1,500 MMF. Available in 10 standard temperature coefficients. Very compact and excellent for u.h.f. applications.

6 **HIGH DIELECTRIC CERAMIC CONDENSERS**—Present units use K1200 dielectric. Maximum available capacitors 5,600 MMF in insulated style and 16,000 MMF non-insulated. Now available in production quantities.

7 **ERIE SILVER MICAS**—Molded condensers that are extremely stable with respect to temperature. Maximum capacity Type K, 500 MMF; Type J, 1,000 MMF. Minimum capacity tolerance ± 1% or 0.5 MMF whichever is greater. Working voltage 500 volts D. C.

8 **ERIE BUTTON MICAS**—Compact silver mica condensers available in a variety of mounting and terminal designs. High resonant frequency makes them ideal for u.h.f. applications. Maximum capacities: Type 370 (illustrated) 500 MMF; Type 470, 1,000 MMF; Type 4700 (illustrated) 3,000 MMF.

ERIE RESISTOR CORPORATION, Erie, Penna.

MILITARY STRATEGY BEGINS HERE...
Tungsten leads, caps and bases must have the essential ruggedness
THE ENGINEERING CO.'s experience in the manufacture of electronic and transmitter tube leads, caps and bases since 1924, is facilitating the Victory program in a substantial measure.
The eyes and ears of war implements and equipment—tanks, fighting ships, planes, submarines, etc. —all require accuracy and dependability in performance . . . for navigation, communication detecting, etc.
Military strategy — to be successful — must have perfect coordination. That's why DANIEL KONDAKJIAN tungsten and electronic tube components are specified in the vital phases and applications.
THE ENGINEERING CO
DANIEL KONDAKJIAN
27 WRIGHT STREET, NEWARK, NEW JERSEY

Hearing Aids

(*Continued from page* 111)

The usual transmitter or microphone is essentially similar to that of a telephone system. It contains particles of carbon which are agitated by sound striking the transmitter diaphragm. Agitation of the carbon particles varies the amount of electrical energy drawn from the battery and so a current is sent out over the wires which is the electrical equivalent of sound pulsations striking the transmitter.

The receiver has a diaphragm which is moved by variations in magnetic force caused by changes in the amount of electric current arriving over the wires from the transmitter. It is found expedient to provide two types of receivers, the air-conduction type and the bone-conduction type. The bone-conduction receiver usually requires more amplification than does the air-conduction receiver. It is, however, useful where hearing deficiencies are caused by troubles associated with the user's outer ear.

Amplifiers are of two kinds, the so-called "carbon" type and the vacuum-tube type. The carbon amplifier will give moderate amplification when supplied with a relatively small amount of voltage and has so far been most widely used in electrical hearing aids because of its relative simplicity. The vacuum-tube or electronic amplifier now coming into more general use requires two batteries of different voltages, an "A" battery to heat the filaments of the tubes and a "B" battery to supply amplifying power. Such a device is capable of considerable amplification. It is also capable of delivering this amplification with relatively little distortion.

Tube Amplifier Advantages

The added amplification available from a vacuum-type amplifier makes it possible to exercise more complete control over the quality of response or frequency characteristic of a hearing aid device.

This is particularly important since it has been found that the auditory deficiencies of people who are hard of hearing vary greatly between individuals. Different people require instruments with different

1933 MARCH 1943
This month marks our 10th Birthday. While our facilities are now first dedicated to the winning of the war, we continue to supply Link "Preferred" FM and AM Radio Communication Equipment and special electronic units for all emergency services such as Police, Fire, Public Utilities and others in Home Defense.
98
FOR GOD AND COUNTRY
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We are proud of our Gang serving in the Armed Forces. You may be sure that they and all their pals —wherever they are—will never lack for the Link radio communication and electronic equipments which we are building in ever-increasing number for them.

Fred M. Link

Engineer • Manufacturer

125 WEST 17th ST., NEW YORK, N.

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240 tests on 120 Circuits in 4 Minutes!

YES SIR! ROTOBRIDGE will test your production tirelessly and faultlessly at this speed all day long—and all night too for that matter. Each circuit is checked for wiring errors, resistance and reactance.

Equipment passed by ROTOBRIDGE is ready for final dynamic checks by your skilled testers.

IF ROTOBRIDGE says "REJECT"—the testers time is NOT WASTED.

Back goes the equipment for repair with a tag indicating the LOCATION of the TROUBLE BY CIRCUIT NUMBER, and the PROBABLE CAUSE.

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An AUTOMATIC, HIGH SPEED
Mass Production Tester

Designed to test all types of ELECTRONIC EQUIPMENT, the ROTOBRIDGE is being used to CHECK COMPLEX UHF UNITS, SIMPLE RADIO RECEIVERS, and MULTI-CHANNEL TRANSMITTERS, to cite a few applications of this new type production tester.

GIRLS CAN BE TRAINED to operate the ROTOBRIDGE in a FEW HOURS as NO TECHNICAL KNOWLEDGE IS REQUIRED, yet the tests on each circuit can be made to any tolerance desired by the production engineer.

The ROTOBRIDGE is priced at $850.00. Descriptive bulletins and reprints of the article on the ROTOBRIDGE from the FEBRUARY ISSUE of ELECTRONICS will be sent on request. DEMONSTRATIONS OF THIS NEW TESTING TECHNIQUE WILL BE MADE BY APPOINTMENT AT OUR PLANT.

Communication Measurements Laboratory

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frequency characteristics to meet their needs.

With the higher amplification available from the vacuum-tube amplifier it is also possible to use higher quality transmitters and receivers even though these have less output volume. Crystal transmitters or microphones may, for example, be used. So also may crystal receivers.

One possible handicap which must be surmounted by vacuum-tube hearing aids is that if they fail in their operation they may go completely dead at once, whereas a carbon type hearing aid usually gives some preliminary warning. Improved components and design will undoubtedly decrease the possibility of such failures in the future. The upkeep of a vacuum tube instrument is also usually greater than that of a carbon type hearing aid because of the cost of batteries and the expense of occasional tube replacements.

Despite a few disadvantages, the use of the vacuum-tube as the means of amplification in the hearing aid has widely increased the usefulness of such instruments and has been the means of bringing satisfactory hearing to additional thousands of people.

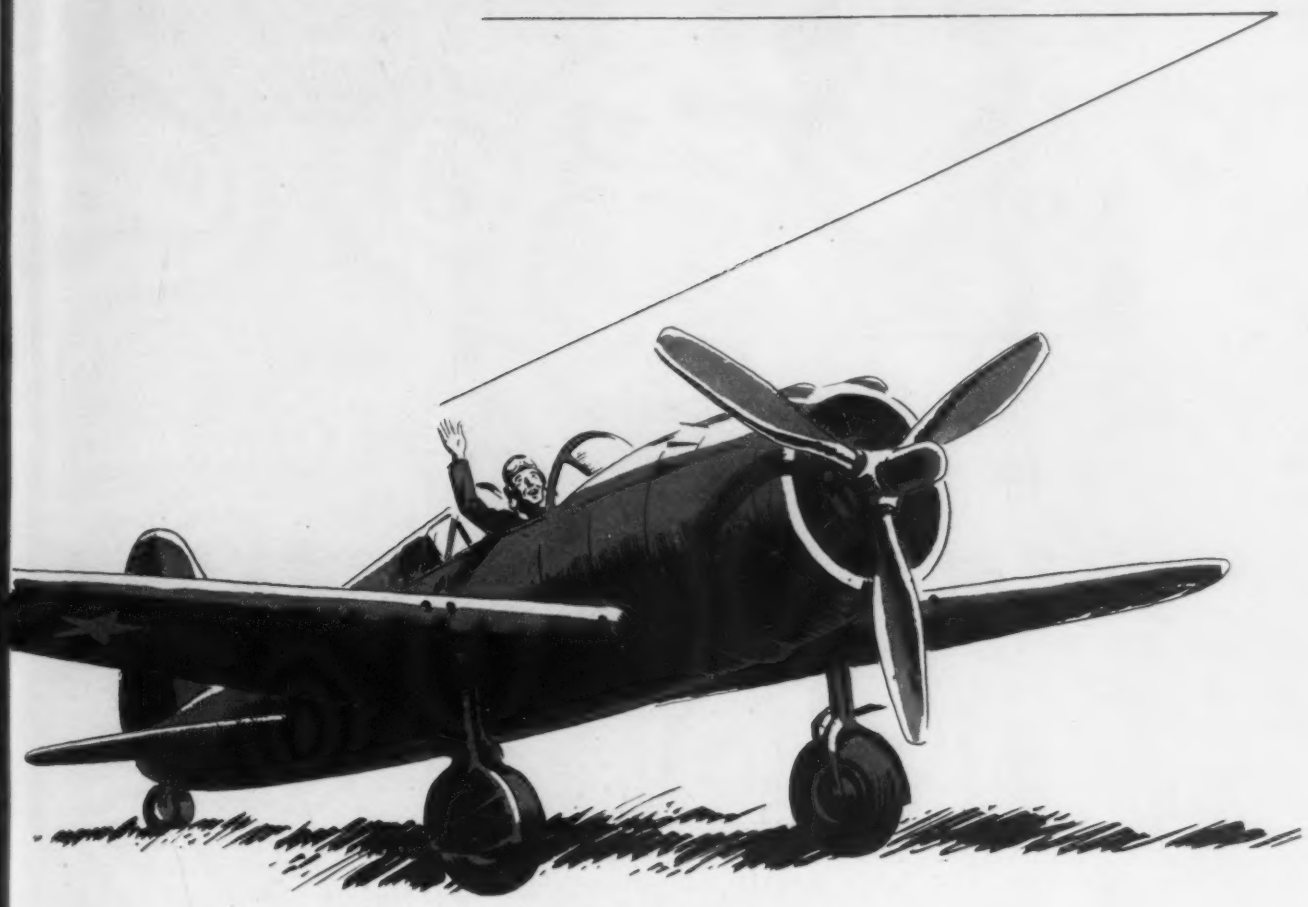
Editor's Note—The market for hearing aid devices of the general type described is by no means limited to individual purchasers. Air-conduction and bone-conduction receivers are frequently installed in certain church pews, or an entire row of theater seats may be equipped, so that patrons afflicted with poor hearing can directly tap speech and music transmitted over the sound systems normally found in such places.

• • •

TELEVISION IN THE NAVY

Navy men, studying high frequency radio to enable them to use the new device for detecting the approach of enemy aircraft, are also being schooled in television. These navy students are being given an explanation of a television control room

CONTACT



Perfect contact is one of the most vital requirements of wartime radio communications. Air-borne equipment, field sets, the jarred and jolted mobile connections in Jeeps and Peeps demand the instant action and uninterrupted contact of all radio and electronic hardware, plugs and connections.

Ucinite specializes in such devices. We make them and put them together. Our engineers are available for the planning, design and development of new devices to meet new problems. And our production men are specialists at getting things done, — and orders put through, — on time.

The UCINITE CO.

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Specialists in ELECTRICAL CONTACTS • CERAMIC SOCKETS • BANANA PINS AND JACKS • PLUGS • CONNECTORS • ETC. ETC.

MICAH* *looks to Electronics*

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**Micah represents the high-grade mica products processed by Macallen.*

Mica is most useful when it is *Macallen Mica.* Long the most positive answer to varied and perplexing insulation problems, Macallen Mica will meet your most exacting specifications. There is no mica requirement that our engineers have not investigated and no new development they are not keenly interested in. If you have something new, call on *Macallen* today. Macallen's 50 years' specialized skill and experience in the insulation field will be a valuable asset to your postwar progress.

50th anniversary book — *Macallen & Mica* — yours *for the asking.*

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Compressed Sheets — Mica Paper, Cloth, Tape, Heater Plate, Compressed Sheet Tubing—Commutator Insulation — Compressed Sheet Washers — Insulating Joints and Canopy Insulators — Railway Specialties — Domestic and Imported Raw Mica.

THE MACALLEN COMPANY

16 MACALLEN ST., BOSTON

CHICAGO: 565 W. Washington Blvd. CLEVELAND: 1005 Leader Bldg.

Photos by Wire and Radio

(Continued from page 113)

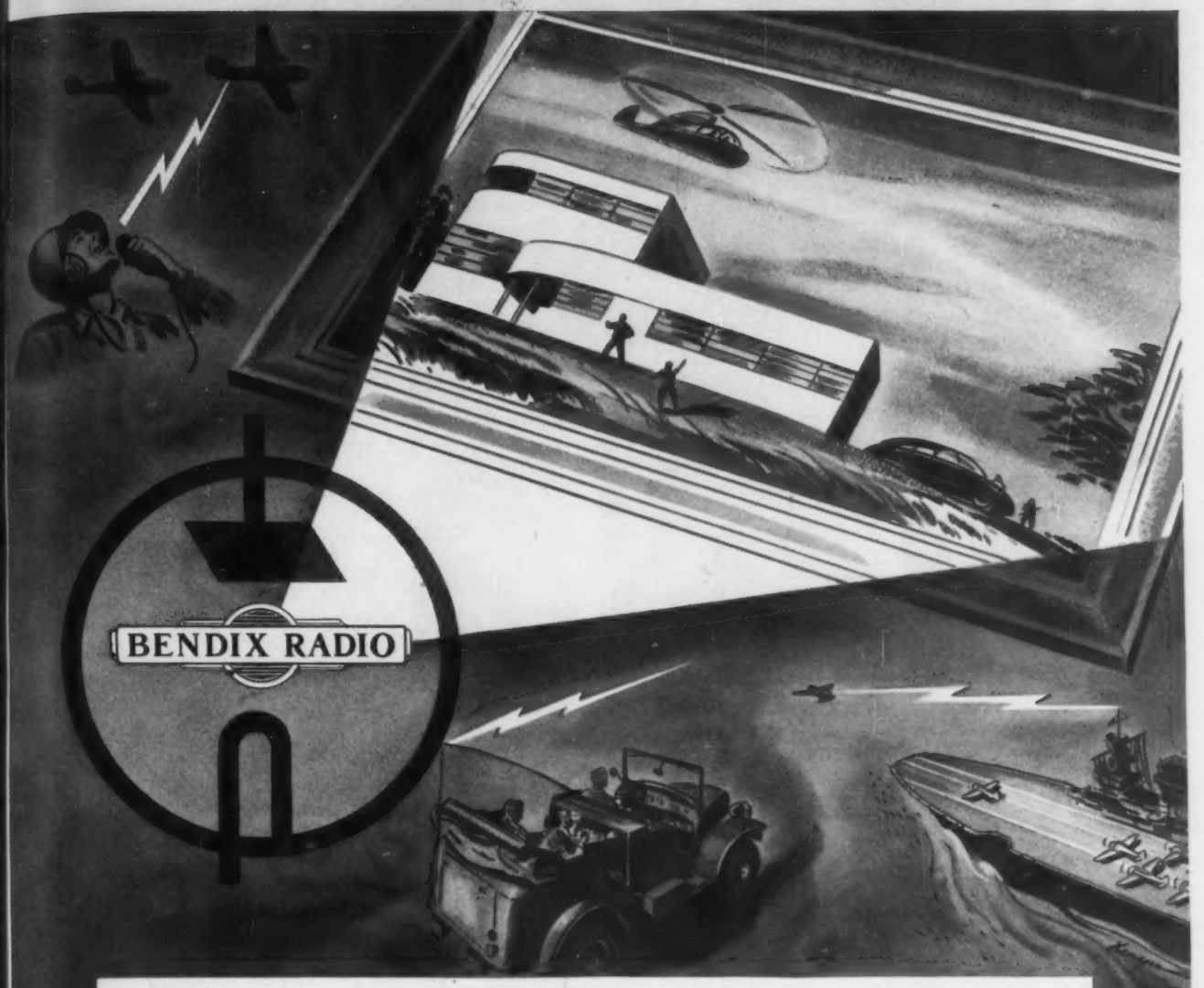
cylinder of a sending machine, a picture half the size of an ordinary newspaper page. Out across the nation in Chicago, San Francisco, Kansas City, Omaha, Syracuse and Philadelphia and in 18 other cities, Associated Press experts made ready their telephones and receiving machines. Eight minutes later in each of the 24 newspaper offices on the network, attendants picked cylinders from their receiving machines and hurried into darkrooms. Another few minutes and finished prints, reproductions of the picture on the sending machine in New York, were in the hands of editors around a 10,000-mile circuit.

Newspapers, large and small, have since benefited greatly from the development. Although the service was expanded, some newspapers elected to receive photos by train or airplane from the nearest wirephoto station. For smaller papers AP began making news picture "mats" at strategic cities on the network and mailing these mats to its member papers. This meant, for example, that pictures on an important story could be sent from San Francisco to New York within a matter of minutes and there could be made into mats for quick mailing to newspapers in the New York area. This system is now nationwide.

Expansion of Service

Coincident with the development of a basic system of transmitting pictures along an established network, engineers worked on the problem of getting pictures from the scene of the story to the nearest sending bureau. While it took only minutes to transmit a picture the necessity for fast handling between the source and the sending machine assumed new proportions. The time thus consumed was important and even greater speed was required.

The solution was a portable transmitting set with means enabling these portable machines to be hooked onto an ordinary telephone line, thus simplifying the transmission of a picture from a news outpost to the receiving equipment wherever it might be.



HERE... Electrons at War Frame the Future!

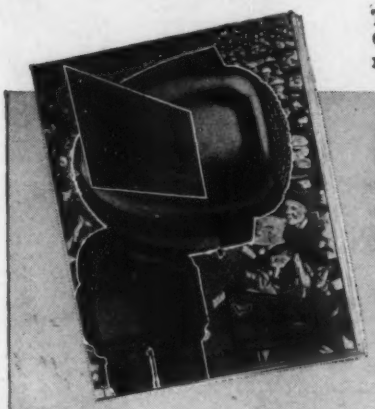
HERE, at Bendix Radio, with each new development in radio communication, radio navigation and radio detection, for the use of our armed forces, electronic discoveries are speeding victory in this war. Just as important, these same discoveries also are throwing fragments in all directions to frame the future. In this future, we see unlimited new fields of endeavor opening up for our fighting men when they return — and for all America. And we realize, as we explore further, that the multiple peacetime applications we envision now, are just the beginning of the new world of electronic marvels we are planning to help build.

Products of Bendix Radio Division are important members of "The Invisible Crew" . . . precision equipment which 25 Bendix plants from coast to coast are speeding to our fighting crews on world battle fronts.

THE INVISIBLE CREW
Precision Equipment by Bendix
AVIATION CORPORATION

BENDIX RADIO DIVISION

Those imaginary pixies that haunt our pilots can also gum up your microphone. Protect your unit from falls, heat, wind, moisture and improper circuit conditions. Above all, use common sense in handling your mike. Don't bang it around as though it were a football. You'll get longer, better service if you treat it right. When your mike fails or gives trouble, send it to the factory or its dealer — don't try home repair jobs!



The back page of the new Turner Microphone Catalog lists the DOs and DON'Ts for longer mike life. It's Free. Send for yours.

Send NOW for your Free Copy of Turner's new 8-page, fully illustrated, colorful Microphone Catalog. Each unit is engineered for specific jobs and trouble-free performance. Select the one best suited to your needs at the price you want to pay.

Free
THIS NEW TURNER MICROPHONE CATALOG

The Turner Company
Cedar Rapids, Iowa

Resistance Welding

(*Continued from page* 119)

they were adapted particularly for high-speed or heavy-welding current applications. In one installation, where ignitron contactors were installed near the ceiling with a saving of valuable floor space, out of a total of 150 contactors installed some four years ago, approximately 50 percent of them are still in use in the manufacture of truck bodies for the armed forces.

The Adjustment Problem

Prior to the introduction of electronic control, welding current was adjusted by the use of taps on the welding transformer. The necessary tap switches were bulky and, unless an excessive number of taps were used, the steps of adjustment were relatively coarse. Since with electronic control it is possible to control the starting of each half-cycle of current, the phase-shifting method of heat control was developed. With this method, a small potentiometer is used for adjustment and the current can be quickly and easily controlled with a fineness of adjustment that cannot be obtained with any other practical method.

Flexibility

With each of these developments, an additional degree of flexibility has been added. It is quickness of response, flexibility and preciseness of control that has steadily expanded the use of a-c electronic control until today our war effort would indeed be impaired without it. Thousands of plants are using this type of control in the manufacture of war products. During 1942, several thousand electronically controlled welding machines were purchased, ranging from the smallest of several kva rating up to some with demands of several thousand kva. In one plant alone there will be installed approximately 800 machines and controls.

Low-capacity controls are being used by the hundreds in the manufacture of the millions of tubes needed, not only for industrial equipment, but to even a greater extent,

Continuous Service Rating Data

TYPES 1550-1560-1570-1580-1590

Maximum Current in Amperes — Maximum Ambient Temperature 60° C

Type 1590

TYPE 1590

Catalog Number	10,000 kc.	3000 kc.	1000 kc.	300 kc.	100 kc.	Cap. Mfds.	Test Volts Eff.	Catalog Number	10,000 kc.	3000 kc.	1000 kc.	300 kc.	100 kc.
1590-200	.....	7.	4.5	1.5	.5	.01	8000	1590-217	.....	16.	20.	15.	8.
1590-201	.....	8.5	6.	3.	1.	.01	6000	1590-218	.....	16.	20.	15.	8.
1590-202	.....	6.	4.	2.	.7	.02	5000	1590-219	.....	18.	20.	17.	10.
1590-203	.....	10.	8.5	4.5	1.5	.03	4000	1590-220	.....	18.	20.	18.	12.
1590-204	.....	8.	7.	3.5	1.2	.04	4000	1590-221	.....	18.	23.	20.	12.
1590-205	.....	11.	11.	7.5	2.5	.05	4000	1590-222	.....	18.	25.	22.	12.
1590-206	.....	9.	8.	6.	2.	.05	2000	1590-223	.....	18.	25.	22.	12.
1590-207	.....	12.	14.	10.	5.	.1	2000	1590-224	.....	18.	25.	22.	12.
1590-208	.....	9.	10.		3.	.1	1000	1590-225	.....	18.	25.	22.	12.
1590-209	.....	12.	14.		6.	.2	600	1590-226	.....	18.	25.	22.	12.
1590-210					4.	.25	600	1590-227	.....	18.	25.	22.	12.
1590						.3	600	1590-228	.....	18.	25.	22.	12.
						.4	600	1590-229	.....	18.	25.	22.	12.
						.5	600	1590-230	.....	18.	25.	22.	12.
						.6	600	1590-231	.....	18.	25.	22.	12.
							600	1590-232	.....	18.	25.	22.	12.
							600						1

Aerovox mica transmitting capacitors are available in the widest range of types, capacities, working voltages. Type here shown is the bakelite-cased 1590 series for medium-duty high-frequency current-handling functions.

Backed by

the most complete CONTINUOUS SERVICE RATING DATA

Those Aerovox mica transmitting capacitors are backed by exceptionally complete data on maximum current-carrying ratings at five different frequencies, in addition to capacity and test-voltage ratings. The unit best suited for given current at given voltage and frequency may thus be selected quickly and precisely. This data, the accumulation of years of research and experience based on extensive tests conducted with special test equipment, was determined in connection with standard circuits in which such units are extensively used.

Good capacitors, *plus* good application data, account for the tremendous popularity which Aerovox transmitting capacitors enjoy today.

Be sure to reserve your copy of the Aerovox Transmitting Capacitor Catalog, now in preparation, for your working library, if you are engaged in professional radio or electronic work.

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Sales Offices in All Principal Cities

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Cable 'ARLAB'

. . . the Highest Standard in Magnetic Measurements

To maintain a high degree of uniform magnetic quality and precision, Arnold engineers use The *High H Permeameter* (illustrated) *. . . a duplicate of the Permeameter in use at the National Bureau of Standards* . . . just one example of the close magnetic control under which the Arnold magnets are manufactured.

All ALNICO types of Permanent Magnets . . . including ALNICO V . . . are completely fabricated in the Arnold plant under exacting metallurgical, mechanical and magnetic control.

Arnold engineers are available to solve your magnetic design problems . . . all inquiries will receive prompt attention.

THE ARNOLD ENGINEERING COMPANY

147 EAST ONTARIO STREET · CHICAGO, ILLINOIS

PRODUCERS OF MAGNETS FOR AIRCRAFT, MARINE, RADIO, ELECTRICAL AND OTHER TYPES OF MEASURING INSTRUMENTS

★ ★ ★

For Victory . . . invest at least 10% in War Bonds

for radio equipment being supplied the armed forces. Many of the metals and alloys in these tubes are difficult to weld satisfactorily without electronic control.

With reference to large resistance welders drawing a thousand or more kva, adequate feeder capacity is a problem. For these applications there has been developed, in addition to the standard controls, controls which can be operated directly from a 2300-volt power supply system, with a direct saving in copper and low-voltage distribution transformers. These same high-voltage controls can be used also with welders having their power-factor corrected by means of series capacitors.

Energy Storage Welding

The tremendous expansion of our aircraft program has required hundreds of precision-controlled resistance welders for welding aluminum and aluminum alloys. Since the resistance of aluminum and aluminum alloys is much lower than that of steel, a much larger welding current is required. Unless power-factor correction is used, this large demand imposes a severe burden on the already heavily overloaded plant distribution system. It was primarily for this reason that stored-energy methods of welding were in a sense redeveloped and refined for use in this country; they have been used for years in Europe.

Energy storage welding has the advantage that the demand is small and power is taken from a 3-phase power supply line instead of a single-phase line, as is usually the case with a-c welding. There are two forms of energy storage welding. One form uses a d-c source, such as a low-voltage rectifier, to store energy magnetically in the primary of a special welding transformer. This energy, when released, inductively produces the necessary welding current in the low-voltage secondary winding of the transformer. With the second form, a high-voltage rectifier (3000 volts maximum) is used to charge a bank of capacitors. When the capacitors are discharged into the primary winding of the welding transformer, the resulting secondary current is sufficient to produce the weld. Since the time required to charge either the special welding transformer or the capacitors is

THE PART BEING PLAYED IN WORLD WAR II BY

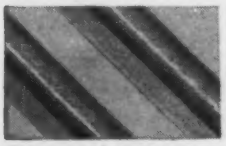
TURBO

IF IT'S TURBO · IT SAFE-GUARDS ·

..and what it will do for you!

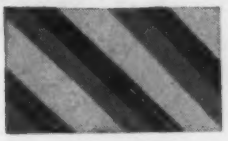
TURBO electrical insulation products have assumed a major role in the military campaign of the United Nations. Wide application in war implements, communication equipment, industrial machines, electronic devices, signaling apparatus, etc., prove the mettle and the need for TURBO Varnished Tubing, Saturated Sleeving, Varnished Glass Tubing, Extruded Plastic Tubing, Wire Identification Markers, etc. Every phase of the war effort will find some TURBO product serving.

This extensive specification at the present time, will have a direct influence on the activities of engineers and designers in the coming future industrial era. New methods and efficiencies, increased assembly and production economies, broader scope and latitude in application . . . all these will be available, and pertinent in the new scheme of things electrical.



FLEXIBLE VARNISHED OIL TUBING

Resistant to deteriorating influences and meeting the diversity of requirements essential to withstand general breakdowns, moisture absorption, acids, alkalis, etc.

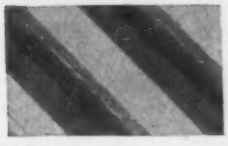


EXTRUDED PLASTIC TUBING

Incorporating the most advanced developments of the plastic art as applied to electrical insulation. Especially applicable to conditions wherein embrittlement from the effects of sub-zero temperatures must be met.

WIRE IDENTIFICATION MARKERS

To meet rigid ordnance specifications, are available in any size, length or color, with any marking. Made of standard TURBO tubing, thereby conserving the use of critical materials such as rubber, metal, visilyte, etc. Non-projecting, snug-fitting.



VARNISHED GLASS TUBING

Resistant to extremely high heat, is perfectly suited for heavy duty operating conditions, confined areas where ventilation is at a minimum, and other similar applications.

For proof ask for samples of each; also for new specimen board and list of standard sizes, no obligation.

WILLIAM BRAND & CO.

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Block Mica, Mica Plate & Products—Varnished Oil Tubing, Saturated Sleeving, Varnished Cambric, Tapes, Cloths & Composites

● We believe every good American wants above all to get this war won. Certainly that is the spirit here in the "Connecticut" plant. But postwar planning is as necessary to the business world as to government.

We do not believe tomorrow's world and yesterday's world have much in common.

We think that many of tomorrow's better things will come from "a little black box" containing automatic electric and electronic equipment. It will do much more than turn things on and off automatically at certain times — it will "look inside" materials being fabricated into finished products, "inspect" transportation equipment to be sure it is safe. It will improve communications amazingly.

This "little black box" is not the invention of "Connecticut" or any other one company. It merely represents the practical application of advanced electrical and electronic principles, many of which are being learned from wartime development. "Connecticut" development engineers will have much to offer the manufacturer who would like to see the magic of "a little black box" applied to his product, or to machines in his plant.

CONNECTICUT TELEPHONE & ELECTRIC DIVISION

ARMY E NAVY

GREAT AMERICAN INDUSTRIES INC.

MERIDEN, CONNECTICUT

long compared to the discharge time the kva demand from the line is reduced appreciably below that which would be required if the energy were taken directly from the power source.

With both methods, electronic tubes are used in the rectifiers and associated controls. Also, as in a-c welding, tubes are required to obtain the necessary flexibility and preciseness of control.

In one plant alone, more than 100 energy storage welders are installed.

Future of Electronic Control

Even though the growth of electronic control has been almost phenomenal during the last several years due partially to the war program, the future is still very promising. Future growth should continue along three lines. First, it is expected there will be a general expansion of its use by practically all metal fabricating industries. Second, there will be continued refinements and modifications in both welding machines and electronic control. Third, new electronic controls will be developed to meet the needs of new resistance welding applications.

With reference to expanded use of electronic resistance welding control, at the present time only 10 percent of the riveting in aircraft fabrication has been replaced by the faster and less expensive method of spot welding. (Experience in this industry indicates that the cost of spot welding can be expected to be 1-½ to 4 mills per spot.) One aircraft design calls for approximately 50 percent welding and if we use this figure conservatively, there is a possible fivefold expansion.

There are a great many fabricators doing sub-contracting, who are now using resistance welding for the first time. When they again go into normal production they will use this method more because of the many savings and high rates of production. In most cases, quality welding is required and this can best be accomplished by means of electronic control.

The machines of the future will be integral units containing the timing control, circuit breakers, sequence controls, and other control apparatus. The trend toward such integral equipment has definitely started and the advantages are that

If you need crystals—promptly—not TOO many—we can supply them. We have set up a special Crystal Service to handle rush orders to small-lot users—in a hurry. When you write—or better yet—phone, a competent crystal engineer will immediately be assigned to your project to insure accuracy, as well as speed. Our service today makes friends for the future for our Family of Activities in the field of Sound and its projection.

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JOHN MECK INDUSTRIES
PLYMOUTH, INDIANA

EXCELLENCE IN MUSIC AND VOICE RECREATING INSTRUMENTS

WE CAN HANDLE SUBCONTRACTS THAT REQUIRE:

- Radio, Electronic or Mechanical Engineering
- Completely Equipped Tool Room
- Automatic Screw Machines
- Hand Screw Machines
- Swaging Operations
- Punch Presses
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- Painting or Spraying
- Infra-red Baking or Air Dried Finishing
- Intricate Mechanical and Electronic Assemblies

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We offer the facilities of our two modern plants to any manufacturer faced with production problems. Our equipment is particularly well adapted to turning out intricate mechanical or electronic assemblies, and we would prefer work involving our assembly department. However, we can accept contracts for any one or more of our production units, except that we are not interested in work which involves only our screw machines.

Our two plants comprise 72,000 square feet of floor space, and we have several hundred trained employees on our payroll. Expert engineering and development services are available. Our company is well financed and now engaged in prime and subcontracts for war production, but is able to take on considerably more.

EVERYBODY EVERY PAYDAY AT LEAST 10%

Address all inquiries to The Ward Products Corporation, 1521 East 45th Street, Cleveland, Ohio.

The WARD PRODUCTS CORP.
CLEVELAND, OHIO

less floor space is required and such equipment is easier to install and service.

Future controls will be simplified particularly for easier servicing. Plug-in arrangements will probably be used to an even greater extent for those plants using a number of machines, so that a new control can be installed with a minimum of down time. In order to simplify and decrease the size of controls, new circuits will be developed using more radio-type tubes and fewer special tube designs.

There are interesting possibilities in the development of electronic controls that will hold the welding current constant even though the line voltage varies. The elimination of this variation would not only improve weld quality, but would permit the use of distribution systems having poorer voltage regulation. Voltage compensators have been developed during the last year to hold the welding current within specified limits for such variations.

There is also the problem of holding the weld current constant when large pieces of steel are introduced into the throat of the welding machine. The introduction of such pieces changes the impedance of the secondary circuit, thereby causing a variation in weld current. Current regulating compensators have been developed to hold this current within specified limits. At the present time these controls cannot be applied universally, but it is expected that they will be soon developed to such a point that they can be applied widely.

As one well-known welding engineer has stated, a number of the steels available today are not formulated from the view-point of strength or ability to form alone but frequently are formulated on their ability to be arc or torch welded. With the weld-ability limit removed, steel manufacturers will be able to give the fabricating industry inexpensive steels of the type best fitted for their needs.

Also, considerable work has been done on the development of the correct process and control for the welding of higher carbon and alloy steels. Information on some of this work is now restricted but, without question, the use of these steels will increase both during and after this war program.

MAGNET WIRE that whips problems of space, heat, cost and performance!

Whether its wire for the magnet of an Army "walkie-talkie" radio telephone or a Boulder Dam generator, the Auto-Lite Wire Division can meet the need, exactly. What is more, Auto-Lite offers an engineering department with the "know-how" to develop special applications and, if necessary, to design new shapes or insulations that fit your needs.

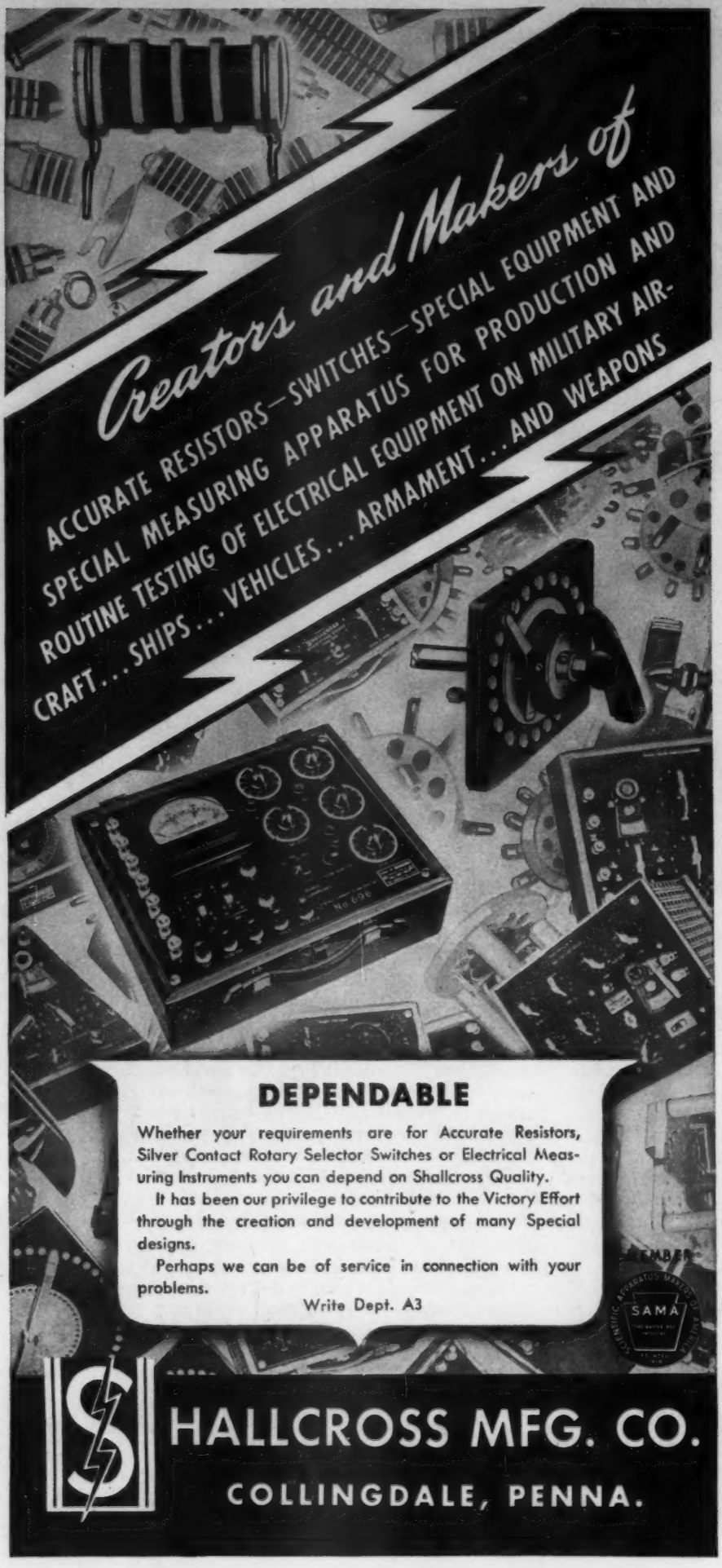
The space-saving accomplishment of Auto-Lite's famous Formvar insulation is typical. Equally revolutionary advances in other types of magnet wire have helped manufacturers perfect products with increased heat resistance, improved performance characteristics . . . and often at decided savings in cost.

Magnet wire can be supplied in all sizes, round, square or rectangular. For further information, authoritative advice or specific recommendations on your problem, write to:

PORT HURON, MICHIGAN · THE ELECTRIC AUTO-LITE COMPANY · SARNIA, ONTARIO
Wire Division

AUTO-LITE ELECTRICAL WIRE and CABLE

ITS 26 GREAT MANUFACTURING DIVISIONS, AUTO-LITE IS PRODUCING A LONG LIST OF ITEMS FOR AMERICA'S ARMED FORCES ON LAND, SEA AND IN THE AIR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CRAFT... SHIPS... VEHICLES... ARMAMENT... AND WEAPONS
DEPENDABLE
Whether your requirements are for Accurate Resistors, Silver Contact Rotary Selector Switches or Electrical Measuring Instruments you can depend on Shallcross Quality.
It has been our privilege to contribute to the Victory Effort through the creation and development of many Special designs.
Perhaps we can be of service in connection with your problems.
Write Dept. A3
SAMA
HALLCROSS MFG. CO.
COLLINGDALE, PENNA.

Property Protection

(*Continued from page* 122)

the electronic age, electronic systems will provide one of the foremost methods of protection.

Undoubtedly, the biggest opportunity will be in the burglary or intrusion detection field, since the success of such systems depends upon their automatic operation.

Invisible light is now being used successfully for detecting intruders and photoelectric equipment for that purpose has been highly developed and widely used. In the future more sensitive phototubes having response further in the infrared will extend the range and scope of this protection.

In still another part of the spectrum sound is being used in thousands of installations for the purpose of revealing attacks upon vault structures. These sound waves are principally within the audible frequency range. In the future it is quite possible that supersonic sound waves in the neighborhood of 20,000 to 30,000 cycles may be employed to establish standing waves or beams of wave energy to detect intrusion.

Just as the heat from stars may be measured by radiometers or bolometers, so may the heat from incipient fires be detected. Using more sensitive versions of these devices the radiant heat from the human body has been found sufficient to actuate an alarm system even over a distance of a few hundred feet.

Unquestionably, the greatest advance will occur in the field of microwaves where electronic development of circuit elements is now receiving such a tremendous impetus due to war needs. It does not require a great stretch of the imagination to see how premises to be protected might be interwoven or encircled with invisible radio waves which if even slightly disturbed would cause a reaction in the associated equipment to signal an alarm.

These few remarks only scratch the surface of what the future may hold in the field of protection based on electronic principles. It would be unwise to prophesy further at a time when much secrecy surrounds many of the amazing developments in the electronic field.

Attention! COMMUNICATIONS EQUIPMENT MANUFACTURERS

We have capacity available to produce the following products for communications equipment manufacturers. Orders can be accepted for prompt delivery on these items. Can they help you speed war production?

HIPERSIL TYPE "C" CORES

Three grades of two-piece, laminated steel cores for power, audio, intermediate radio and higher frequencies. Space factors 95%, 92% and 89%. Windows down to ½" x ¼". These cores do not require dies or nickel.

PRESTITE—CERAMICS

"Solder-Seal" hermetically tight bushings and terminal boards; standoff insulators, coil forms, bushings. Grade "F" characteristics.

MICARTA—PLASTICS

Phenol-formaldehyde, thermosetting. 11-NEMA Grades including XXX; X; P; and LE. Sheets, shapes, punchings, moldings.

TUFFERNELL INSULATING MATERIALS

Varnished cambric and cotton tapes; synthetic, air drying and baking varnishes; thinners; compounds and enamels.

RECTOX—RECTIFIERS

Copper oxide rectifiers for power packs, instruments, etc.

BI-METAL THERMOSTATS

Strip and disc type. For temperature control in crystal ovens, humidity control, etc.

INERTEEN CAPACITORS

Noninflammable, hermetically-sealed, very compact. Ratings from 10,000 to 100,000 volts.

DYNAMOTORS

Types PE-59, 60, 86; DM-25, 32, 33, 34, 35, 36, 45, 53.

BLOWER MOTORS

400-800 cycle models, 6700 rpm, for cooling radio transmitters.

For further information on products or deliveries, wire or write to Communications Division, Dept. 10-L, Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

J-94545

Westinghouse

PLANTS IN 25 CITIES . . . OFFICES EVERYWHERE

Thermador Transformers are Thermatite treated to withstand extreme temperatures and humidity—arid or moist heat—dry or damp cold do not hamper their efficiency. Thermatite is the name of a process of accurate heat controlled vacuum impregnation developed and improved over a period of ten years.

THERMADOR
THERMATITE TREATED
TRANSFORMER

THE THERMADOR TRANSFORMER LINE

Included in the Thermador Transformer line are audio, auto, geophysical, bias supply, bridging, cathode modulation, coupling, driver, field supply, filament, high fidelity audio, input, midget plug-in audio, mixing and matching, modulation, output, plate, power, television, and tube-to-line transformers. Filters, chokes, and reactors.

THERMADOR ELECTRICAL MFG. COMPANY
5119 S. Riverside Dr., Los Angeles, Calif.
"Seven Leagues Ahead"

Detection

(*Continued from page* 133)

waitresses walk through quickly quietly, and without fatiguing door pushing. In factories that employ hand trucks, motorized inter-building carriers and people carrying bundles frequently, it is a considerable economy to save the time each requires to open a door. Throughout a day, the savings in time and fatigue for such employees and for the drivers of trucks is greater by far than the cost of operating the door automatically.

Garages employ photoelectrically controlled electric doors to open and close the overhead rolling door for autos and trucks. The saving in heat, plus the saving in personnel make this worth while.

Phototubes also control automatic signals at road intersections for changing the traffic signals only when traffic requires it, and making unnecessary the time-consuming stops and starts to traffic that often are made without need.

A photoelectric installation on a main road is more likely to be a counting machine, to determine the amount of traffic on the road at each period of day or to record the speed at which cars go past.

A photoelectric system has been developed, and awaits normal times for tryout, by which traffic is permitted to move along a highway until a car exceeds any desired speed limit. Then the lights turn red, forcing the car to stop at the next intersection to be penalized. When traffic thickens up enough to warrant it the same photoelectric control turns itself into a traffic regulating system and permits cars to move along the highway or across intersections at a rate depending upon the conditions at the moment.

Racetracks often employ phototube devices for the "photo finish" of the race. In this equipment, a beam of light across the race track near the finish line is interrupted by the first or winning auto or horse; this operates photographic equipment, usually in the form of a motion picture camera, which takes a series of photographs as the leading contestants pass the finish line. The small amount of film involved is readily developed and examined without loss of time, and invariably

HELLO JANET, I'M TAKING THE NOON PLANE

The marvels in electronics developed during the war will not pass with the war. Their application to post-war life will be as wide and amazing as only American imagination and enterprise can make them.

More efficient hearing aids, inexpensive ship-to-shore phones for small craft, wireless intercommunications systems for business, improved counting and color sorting devices are but a few of the obvious developments of existing electronic applications. Even portable, personal two-way radio phones may become a reality. Where electronics will take us no one can foretell.

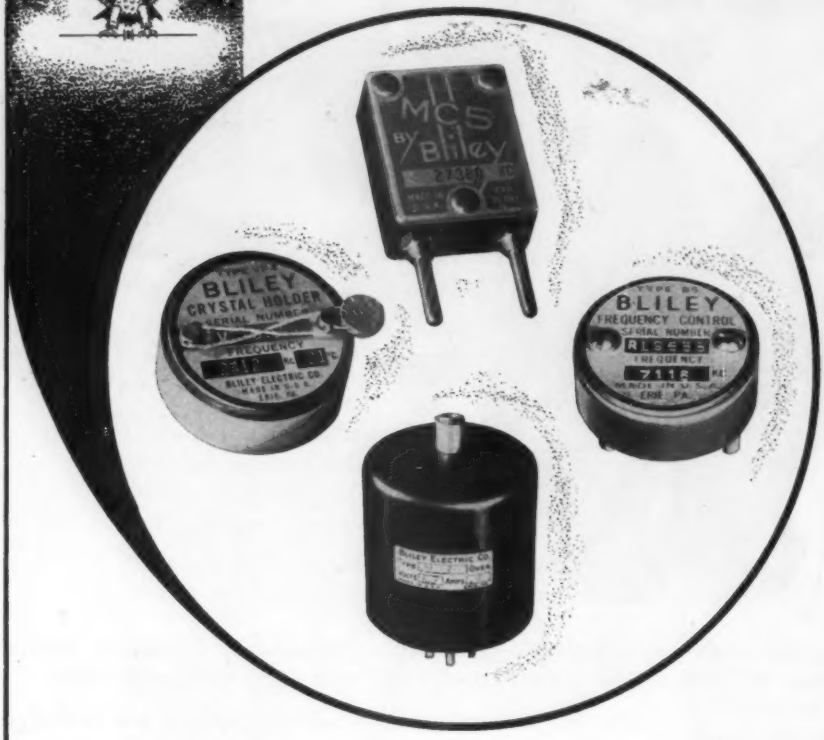
In this time of need, it is TUNG-SOL'S job to design and produce necessary transmitting, receiving and amplifying electronic tubes for our government. After the war the new experience so gained will be at the disposal of those who will be instrumental in building the new electronic era. Manufacturers will find at TUNG-SOL a wealth of equipment, engineering and production skill to help them make new or better electronic devices.

TUNG-SOL
vibration-tested
RADIO TUBES

TUNG-SOL LAMP WORKS INC., NEWARK, N. J., *Sales Offices:* ATLANTA, CHICAGO, DALLAS, DENVER, DETROIT, LOS ANGELES, NEW YORK
ALSO MANUFACTURERS OF MINIATURE INCANDESCENT LAMPS, ALL-GLASS SEALED BEAM HEADLIGHT LAMPS AND CURRENT INTERRUPTERS

Bliley CRYSTALS

for All Quartz Crystal Piezoelectric Applications



TODAY, the entire output of Bliley Crystal Units is directed to vital communications equipment for war purposes. When the United Nations win the last battle, as they most certainly will, the fruits of increased engineering knowledge, expanded facilities and improved production technique, will be available to a peace time world . . . a new world of greater human comfort through applied engineering and science.

In this new world, Bliley Crystals will take their rightful place with their pre-war record of dependability, accuracy and user acceptance. Not counting applications covered by war time secrecy necessities, there will be Bliley Precision-made Crystals for diathermy, ultrasonic generators, pressure gauges, carrier-current communications systems, radio frequency filters, and precision interval timers. And, of course, in greater quantities than ever before, frequency controlling crystal units for all radio communication necessities, F. M. or A. M., fixed, portable, mobile or air borne. As always, Bliley Engineers are ready to extend their assistance to you . . . call on them freely.

BLILEY ELECTRIC COMPANY
UNION STATION BUILDING . . . . . ERIE, PA.

some one in the group of pictur shows the winner just at the fini line, and the other contestants f lowing him. With a clock and cale dar, and a card showing the numb of the race and the name of t track, all in the picture, this phot graph becomes an indisputable, pe manent record.

Special Purpose Robots

The ultimate objective in all a tomatic control systems is to fi an assembly of equipment capable doing a job that a person does n want to do or cannot do or to do better (faster, cheaper, more accu ately, etc.,) than a person could d it. It matters not to a good electron engineer whether the tube used is phototube, or an amplifier or a combination of the many forms tubes now available. His job is see that the apparatus perform the desired job with a cost and a curacy at least commensurate wit other means of doing the same tas Very often the tube itself is a ver small part of the entire system; mo of the complexity coming betwee the tube and the final control appa atus. Often the initiating impuls may be derived very simply and ver ingeniously.

Electronics now controls elevat doors in several ways. Light beam shining across the door of large de partment store elevators preve the doors from being closed so lon as any part of the passenger or h purchase obstructs the beam. Phot tubes may accurately level the el vator at the floors at which it is stop. In another leveling system t cars carry a small vane of met which is caused to be interposed b tween two coils of an oscillator tu system, and thus to accurately sto and level the elevator at the desire floors.

The same principle of elevator co trol may be used to automatically cu off desired lengths of steel rod, pape tubing, rubber slugs, etc. Some for of machine or conveyor pushes t material involved out at a fast rate when the material has moved out fa enough to intercept a beam of ligh or to enter a coil and influence th electrical qualities of the coil, or t operate a contact device, then a cut off mechanism is caused to operate Depending on the requirements o the job, the cut-off may be designe for extreme accuracy, for simplicity

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IF your problem is one of transmission of power or control "around the corner," you will generally find the answer in Walker-Turner Flexible Shafting.

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and ruggedness of operation, or for low cost without high accuracy.

Automatic Registering Systems

Remove the printed wrapper from any package of food, and there is a good chance that you will find a rather heavy black stripe on it, near one edge. This usually means that the package is wrapped automatically, and that a phototube is used to look at this stripe and thereby "register" the cutting of the wrapper accurately with the printing. The paper is printed in rolls and is drawn through the machine until the stripe comes under the phototube. Strong light, reflected off the paper, provides an image of this stripe as the paper moves by. The image is transmitted through a slit onto a phototube and causes a sharp decrease in the amount of light arriving at the phototube. Through amplifiers and electromagnetic equipment, this furnishes an impulse which determines whether the next cut should take place a little earlier in the cycle, or a little later in the cycle, or at the same instant in the cycle. As a result, the position of the cut with respect to the printed design on the wrapper is being continuously readjusted and therefore cannot stray off.

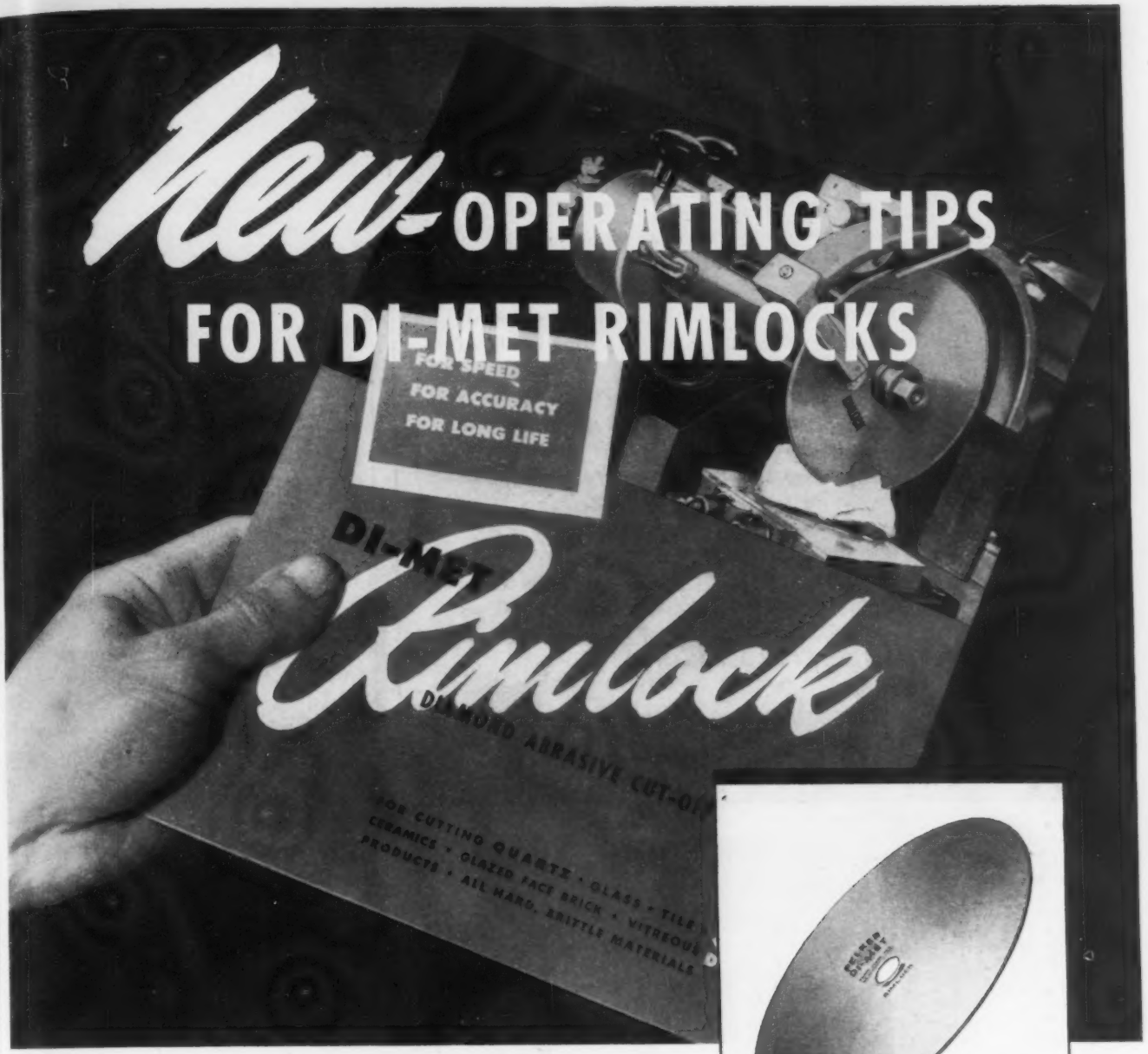
The four-color printing which so beautifully adorns some of our newspapers and magazines is made possible by similar equipment also. Phototubes find the stripe which is a part of each color plate, and change the position of the printing of each succeeding color to assure accurate registration of one color with another.

Future Prospects

It is possible, in a review of this extent, merely to touch upon the several places in industry where tasks of the sort described are performed by electron tubes. Many hundreds of other applications could be described, all beginning with the detection of a change in some physical, electrical, or chemical property and leading to a control of that property.

One thing is certain—in the new world all of us look forward to, after the war, there is little reason why so many of the repetitive tasks of drudgery now done by man cannot be replaced by electronic devices, thus relieving man for more important and dignified jobs.

New-OPERATING TIPS FOR DI-MET RIMLOCKS



Recommended procedures that cut more quartz per blade, increase cutting speed and improve surface finish

This new DI-MET RIMLOCK folder provides up-to-date information on proper Rimlock operation when used for cutting quartz. It covers such subjects as speeds, feeds, coolants, sharpening and power . . . explains causes of unnecessary dulling and how to avoid them . . . recommends proper feeds for maximum production and long life . . . tells why Rimlocks cut faster! Your copy will be mailed immediately upon request.

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If *you* have ideas for post-war products, we would like to hear from you. Our engineering staff and well-equipped factory are capable of developing and producing your ideas.

We will pay you for them, of course. As a first step we suggest that you send us a letter telling what you have in mind. Address it to Max L. Haas, President, Bud Radio, Inc., 2118 East 55th St., Cleveland, Ohio.

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Export Dept. 100 Varick St., N. Y. C.

Geophysics

(*Continued from page* 137)

0.1 seconds or more. This furnishes a criterion for deciding whether a wave is refracted or reflected. Recordings made simultaneously with pickups covering at least two sides of the shot point afford additional data for identifying the reflections. The time from the instant of explosion of the dynamite charge to some definite characteristic of this event is counted to the nearest one thousandth second; the depth to this reflecting horizon is then computed from these times. Thus, contour maps can be drawn of the subsurface strata at depths of from a few hundred feet to around 20,000 feet. Carrying the survey over a large area, subsurface anomolies where petroleum might exist may be detected.

In the reflection seismogram shown, six reflection channels are recorded with the seismic pickups placed two hundred feet apart and in line with the shot point. The instant of explosion of the dynamite charge is shown at *A*. The refracted waves recorded on the six galvanometer traces represent the first arrival at the individual pickups of the impulse due to the explosion. The point marked *B* on this seismogram indicates a prominent shallow reflection. The succeeding events at *C*, *D*, *E* and *F* are also reflections. The reflection at the point marked *G*, which occurs at a time of 2.327 seconds after the explosion, corresponds to a depth of approximately 10,000 feet. Beyond the reflection at *G*, ground disturbances due to wind and traffic movements obscure any further reflections.

The velocity of propagation of the seismic wave depends upon certain properties of the medium through which the wave passes. If hard rocks are involved, the velocity of propagation may be 8,000 to 20,000 feet per second. If the materials are soft, the velocity will be much less than this. In some instances, the velocity of propagation through certain shallow formations is even less than the velocity of transmission of the sound wave through air.

Characteristics of the Pickups

The seismic pickups used for detecting the seismic reflections are somewhat similar to the microphones

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used in broadcast stations. They usually consist of a suspended mass that is connected to some form of generator of electrical energy. These pickups, like the broadcast microphone, may take the form of the carbon button, piezo-electric, condenser type, moving-coil type or moving-armature type microphone. The moving-armature type, known as the variable-reluctance type, and the moving-coil type are very widely used in the reflection seismograph method. These types are very rugged

AMPLIFIERS—Battery of 24 reflection-type seismographic amplifiers

and have a stable sensitivity, important features of all instruments used in geophysical exploration work. The seismic pickups shown are of the variable-reluctance type. The coil is designed to work into a low-impedance winding of the input transformer of the amplifier. Some idea of the necessary sensitivity may be obtained from measurements made on this type of pick-up.

The frequencies of the reflections vary from about 20 cycles up to around 80 cycles, depending to some extent on the elastic properties of the deep formations and to a greater extent on the properties of the formation in which the explosion occurs and on which the seismic pickups are located. The frequencies of the direct waves are in general lower than the reflection frequencies, and the frequencies of the extraneous disturbances caused by wind and

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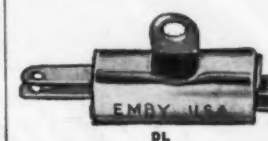
N-2 — Input 5 volts. Half wave. Continuous dc current 1 ma. Used with meters, detector circuits, bias voltage.

H-SM — Input 5 volts. Half wave. Continuous direct current 8 ma. Numerous field applications.

B-SM — Input and output same as H-SM, but has two rectifying elements connected in series.

DS — Input 10 volts. Full wave Bridge. Continuous dc 10 ma. Unbreakable plastic case with mounting extension.

CENSORED — Input 10 volts. Full wave. Continuous dc rating 35 ma. Mounted in



DL — Input 10 volts. Full wave Bridge. Continuous dc rating 35 ma. Mounted in aluminum case with mounting extension.

P-1-M — Input 10 volts. Continuous dc rating 50 ma. Mounting extension available if specified.

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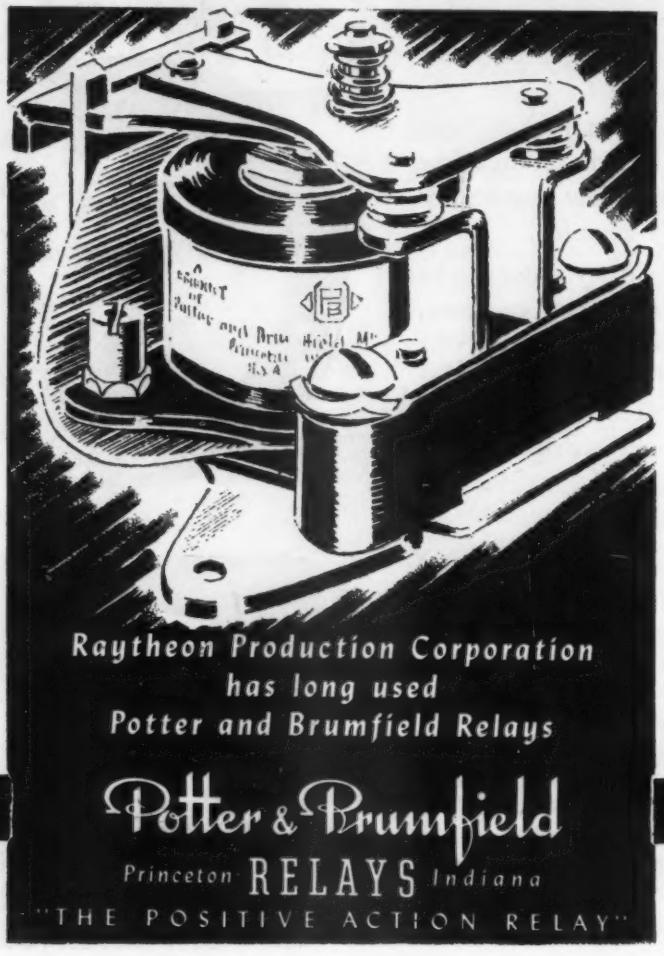

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Princeton RELAYS Indiana
"THE POSITIVE ACTION RELAY"

traffic are usually higher than the reflection frequencies. The usable sensitivity of the electronic equipment is, therefore, increased when filter circuits favoring the reflection frequencies are used. The amplifiers used in reflection recording are usually equipped with variable band-pass filters covering the reflection frequencies in order that minimum dynamite charges may be used.

The energy from the dynamite explosion decreases approximately exponentially with time; that is, the movement of the earth is many times greater at two tenths of a second after the explosion than it is at two seconds after the explosion. It is desirable to have a recording of all the seismic channels on the seismogram at an amplitude range that on the average remains approximately constant and yet retains the relative changes in amplitude of the successive cycles. To accomplish this, it is essential that some special automatic gain-adjusting circuit be incorporated in the seismic reflection amplifier. This amplifier consists of five stages of amplification with band-pass filter and coupling networks distributed between the stages. When the shot is fired and the output of the seismic pick-up located nearest the shot point is impressed on the input of the amplifier the relay system is energized. This relay switches all the amplifiers from a given sensitivity and frequency response adjustment, for recording the refracted waves, to the automatic gain-adjusting setting and frequency response for recording reflections. The camera interlock permits the control to operate while a record is being made.

Radio Communication in the Field

Radio communication is used in preference to telephone lines when the operating truck containing the recording instruments is located a long distance from the shot point or when the intervening area is traversed by wooded sections or streams. Low-power transmitters are satisfactory for this purpose as the distance seldom exceeds five miles. Except for the features adopted to obtain light weight and rugged construction, the general design lines follow broadcast practice. When the charge of dynamite in the hole at the shot point is exploded, the electrical circuit to the cap is broken. The electrical impulse that results

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from this sudden break of the c current is impressed on the mod lating section of the transmitter a a signal is emitted at the instant explosion. This signal is in turn r ceived at the recording truck and r corded by a moving-coil galvano eter in the recording unit. Voi C.W. and I.C.W. modulation a used for communication purposes.

Electronics Employed in Drilling a Analysis

In addition to the use of electron equipment by the exploration gro for locating a likely place in whi to drill the well, it is used by t production group while drilling a completing the oil well. The vacuu tube and electronic circuit techniq are indispensable in the recently d veloped gamma-ray electrical w logging method; also in other w logging methods where measur ments are made of the electric acoustical or other physical pro erties of the earth formations tr versed by bore holes. Electronic a paratus is also used in modern mu logging equipment. While the well is being drilled, continuous a alysis of some of the chemical an physical properties of the mud us as the drilling fluid is made possib by the application of electronic co trol equipment especially design for this purpose. Data obtained e able the geologist and petroleum e gineer to arrive at a clearer unde standing of the conditions in t bore hole and aid in the final co pletion of the oil well.

Electronic equipment plays an i portant part in talk-back syste used on the drilling rig. Talk-ba systems that supply the means f intelligible communication from t fourble board near the derrick's t to the noisy derrick floor decrea the hazards and help co-ordinate e forts in handling heavy drill pipe.

Modern radio transmitting a receiving equipment is used at so of the oil well drilling rigs located the swamps and other isolated are The use of radio in this manne brings the facilities of the telepho system to the oil well derrick floor.

BIBLIOGRAPHY

Nettleton, L. L., "Geophysical Prospecti for Oil", McGraw-Hill Book Co., N. 1940.
Jakosky, J. J., "Exploration Geophysics Times-Mirror Press, Los Angeles, 1940.
Heiland, C. A., "Geophysical Exploration Prentice-Hall, N. Y., 1940.
Heiland, C. A., "Geophysics in War", Colora School of Mines Quarterly, Golden, Colo.

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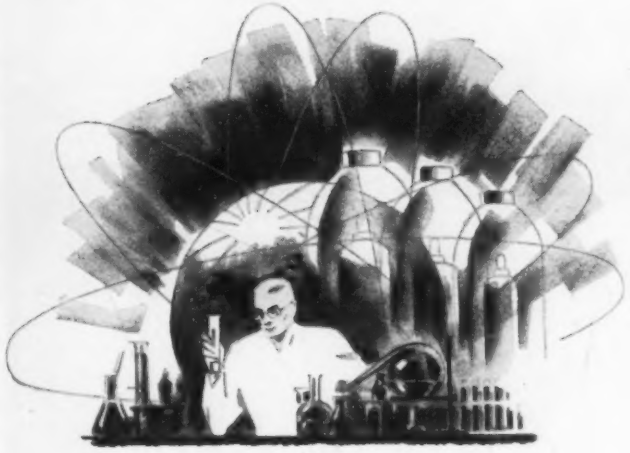

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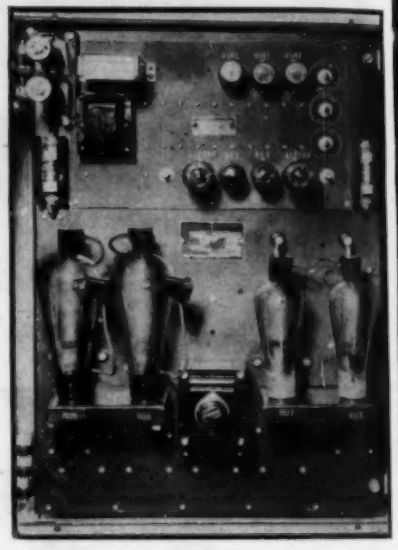
Motor Control

(*Continued from page* 139)

widely, but because the development of versatile electronic controls now makes it possible to obtain all of the advantages inherent in d-c motor applications, a tremendous extension in the application of d-c motors can be expected.

The future of the electronic drive is well reflected by its many advantages shown in the accompanying table.

Thus far, the full automatic electronic motor controls have been confined to motors of relatively small size. Fundamentally, however, there is no reason why similar controls cannot be applied to motors of any size so long as suitable tube combinations are available for handling them. When the limit of the thyratron tube has been reached, it will undoubtedly be possible to employ the pool-type ignitron tubes in suitable circuits.



PACKAGED—Typical electronic control unit for d-c motor.

Since motors may be considered one of the bread-and-butter items of industry, and since the electronic motor control makes possible still greater advantages than can be obtained with conventional equipment, it appears evident that the electronic motor control is destined to be a very important factor in the growing industrial electronic business and that past applications are but indications of the future possibilities of electronic drives.

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Medical Science

(Continued from page 145)

duced by these screens adds to the effect of x-rays on the emulsion.

When x-rays strike the body, secondary rays are produced. These radiate in all directions, and have a tendency to fog the film. An ingenious device for the prevention of this effect is the Potter-Bucky diaphragm, which consists of alternate thin laminations of lead and wood. They are so placed that they are perpendicular to the film. The diaphragm is moved constantly during the exposure, so that no shadows of the lead strips are visible.

One of the more recent applications of electronics to roentgenographic technique is the photoelectric exposure control, which automatically ends the exposure after the proper amount of radiation reaches the film.[1] It operates by means of a multiplier-type phototube (RCA 931) connected to the grid circuit of a thyratron, with a condenser in parallel. The x-rays are changed into light by a fluorescent screen placed near the phototube.

In 1898, three years after the discovery of the rays, they were used to observe the movement of the stomach in the dog, followed shortly by their application to man. Bismuth paste was used, which when ingested made the gastro-intestinal tract opaque to x-rays. Barium sulphate is now used, because of its lesser toxicity. The movements and outlines of the human stomach could then be observed and photographed. This was of inestimable value in the early diagnosis of various abdominal conditions, the nature of which could otherwise be determined only by an exploratory operation.

Since that early day many new techniques have been devised, based on the development of non-toxic opaque materials, so that it is now possible to inject contrast media into the urinary bladder and kidney pelvis, into the spinal canal and the ventricles of the brain, and it is even possible to radiograph the blood vessels and the cavities of the heart. The location of clots in the veins of the leg may be accurately determined, and removed surgically if necessary.

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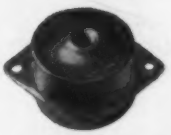
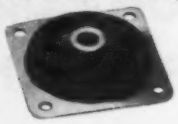


Square Plate Form V.S. Mounting



Square Plate Form Mounting

Square Plate Form Series Mounting

Tube Form V.S. Mounting

Tube Form Mounting

MILLIONS of Lord Mountings are at work today in the electronic industry—protecting all manner of electronic devices from their worst enemy—vibration. The transmission of unbalanced forces causing vibration is reduced to a minimum by means of Lord Mountings, with the result that, in any electronic device, operating characteristics are improved and functional life is increased.

The principal characteristic of any Lord Mounting is the strong bond between the rubber and metal—a distinctive feature which makes possible the design and manufacture of *Shear Type* mountings that are rugged, simple, compact, and easy to install.

Standard Lord Mountings are made in two main types—Plate Form and Tube Form—in various shapes and sizes, with snubbing and non-snubbing features, and in load capacities ranging from a few ounces to 1500 pounds.

The first step in the selection of mountings is to determine the actual static load to be carried and the nature and direction of the disturbing frequency. When loaded so that the disturbance is in the direction of the main axis of the mounting, the mounting deflects readily and the rubber is permitted to operate in full shear freedom, with ample stability in other directions. This action results in a considerable reduction of the natural frequency of the mounted system with a consequent great reduction in the vibratory forces transmitted through the mounting. All Lord Mountings will withstand momentary overloads due to shock greatly in excess of static loadings.

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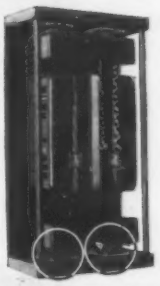

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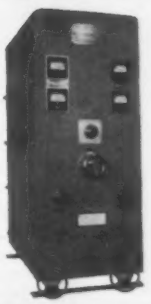

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be injected into the uterus to test the potency of the Fallopian tubes. Various other iodine compounds have been developed, which may be given by mouth or injected intravenously, and which will be excreted into the gall bladder or urinary tract and permit their visualization without instrumentation.

X-ray has also been widely used in the treatment of various diseases, mostly dermatological conditions and tumors, which are more sensitive to the rays than normal tissues. Although surgery is the method of choice in the treatment of most malignant tumors, x-ray is an important adjunct used pre- and post-operatively. It is also a widely used and beneficial palliative measure.

In general, higher voltages are used in therapy than in diagnosis. The high potential (above 100 kv) imparts to the electrons in the Coolidge tube an extremely high velocity, resulting in rays of short wavelength and great penetrating power. The rays are thus able to reach the tumor without being absorbed by the overlying tissue.

There has been considerable publicity about the potentialities as "cancer cures" of new high-voltage x-ray machines, and even more about the devices of the physicist which emit various sub-atomic particles. They are undoubtedly more effective than the lower-voltage devices, but it is very doubtful if they will actually cure any but the most superficial malignancies.

High-Frequency Heating Is New Medical Aid

The application of heat to an injured or diseased part of the body is one of the oldest forms of therapy, long recognized as of value in surface conditions, as well as aiding deep-seated inflammations. Its exact method of operation is not fully understood, but appears to be due to the direct effect of heat on the blood vessels of the injured tissue, producing dilatation and resulting in a greater flow of blood. Its effect on deeper tissues, to which the heat cannot penetrate, is reflex in nature, mediated by the nervous system. It follows logically from the above considerations that a method of applying the heat uniformly throughout the affected part would be of great value.

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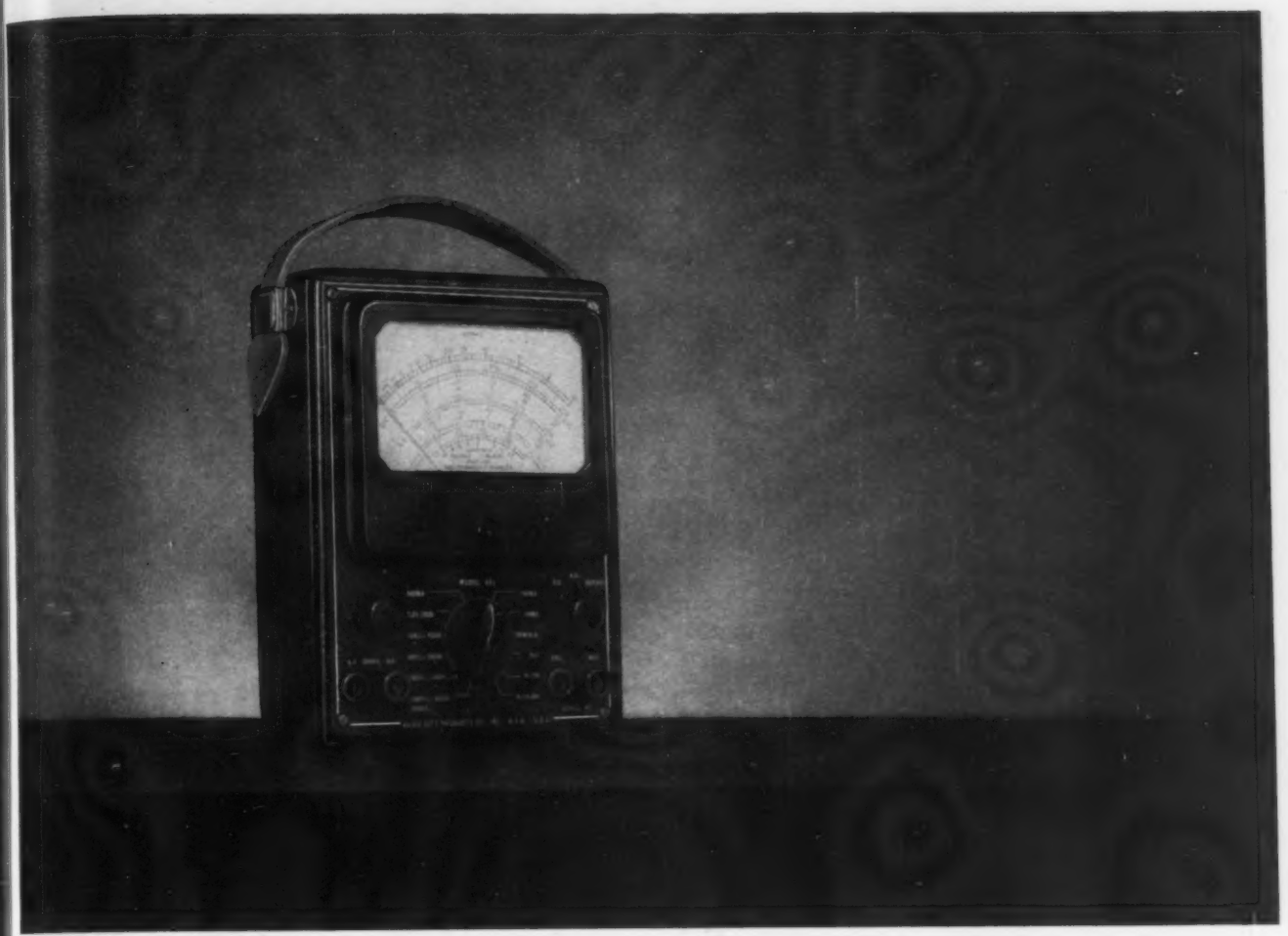
century laid the ground-work for our present-day diathermy. Their results led to the work of Dr. d'Arsonval, who began about 1890 to conduct experiments on the biological effects of high frequency currents. He applied these currents to muscle, and found that the muscular response increased with increasing frequency up to about 5,000 cps, above which point the response decreased, and ceased altogether at about 10,000 cycles. Using frequencies as high as one megacycle, he was thus able to pass considerable current through his body with no subjective effect other than a feeling of warmth due to the ohmic resistance. He was the first man to pass the current for an electric light bulb through his body, a feat which was later duplicated by "renowned scientists" in every well equipped carnival. Apparatus of this type began to be used for the production of deep heating by the medical profession early in the present century, and the first World War provided an impetus to its more general use.

The use of higher frequencies was begun about 1925, with the development of large transmitting tubes. Vacuum tube oscillators have now almost entirely replaced the older spark-gap equipment. Most of the diathermy apparatus used at the present consists of self-rectifying push-pull oscillators with an output of 200 to 300 watts, at a wavelength of 6 to 12 meters. There are several methods of applying the current to the patient, depending on the area to be treated and the type of equipment available. The radio-frequency high potential may be applied to metal plates, which are either held firmly to the skin of the patient or held a centimeter or so away from the skin by rubber pads. Because of the high frequencies used the latter method is almost as efficient as the former. Another widely used technique is to place a coil through which the r-f current is flowing around the part to be treated. In this case the effect is due to a combination of capacitive and inductive heating.

The use of malarial therapy for syphilis had been shown to be moderately successful, and Whitney of General Electric conceived the idea of using diathermy to raise the temperature of the entire body. The cabinet designed by him consists of



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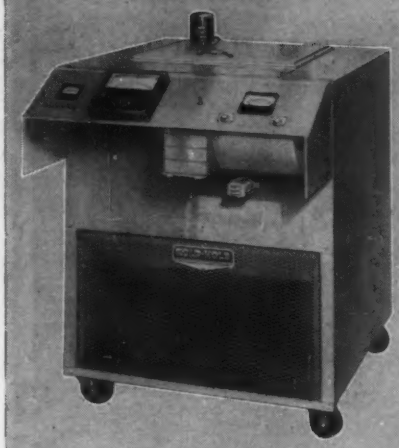

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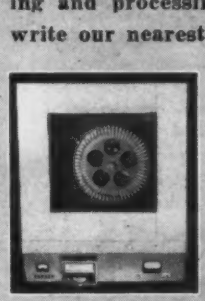

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a horizontal box in which the patient is placed, having a coil around it to which the current is applied. Only an ordinary oscillator need be used, as a sufficiently high temperature is maintained around the patient to prevent loss of heat, and it is comparatively easy under such conditions to reach the desired temperature (about 106° F) with minimum power. Excellent results have been obtained by a combination of chemotherapy with hyperpyrexia, but such treatment is not without danger, and the popular accounts written by non-medical men should be discounted considerably.

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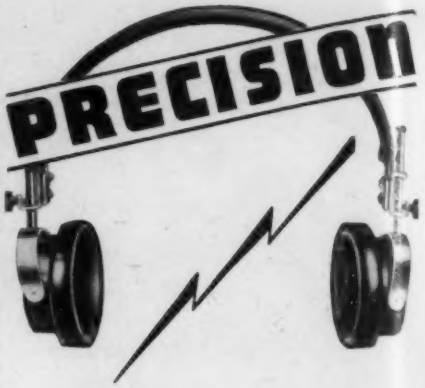
One of the most useful applications of diathermy is in surgery. In medical diathermy the current flows in a wide area, producing moderate heating. In surgical diathermy, the so-called radio knife, a large indifferent electrode is placed on the patient's back and the current passes from a small electrode to the tissue, producing a high temperature in a small area. This current may be varied in its characteristics so that it will have a predominant coagulative or cutting effect. Surgical diathermy has revolutionized neuro-surgery by making possible rapid hemostasis in friable brain tissue, where the slow and laborious application of silver clips was previously necessary. It has also made possible the modern transurethral prostatectomy, as the coagulating power is little impaired by operation under water.

Electrocardiograph Records Potentials of Heart

The electrocardiograph is a device sufficiently familiar to the patient so that if he is worried about his heart he will usually ask his doctor about taking an electrocardiogram. The fact that a difference of potential is produced on the surface of the heart during contraction was first discovered in 1856, and in 1887 Waller showed that the potential could be led from two parts of the body which had the heart between them, using the capillary electrometer as the indicating device. This ingenious but rather primitive device could not accurately record the rapidly changing cardiac potentials.



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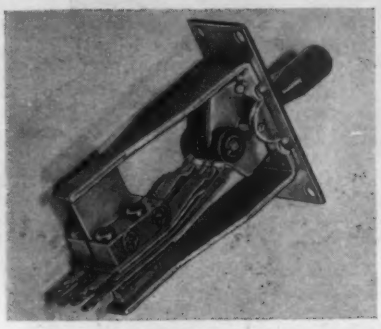

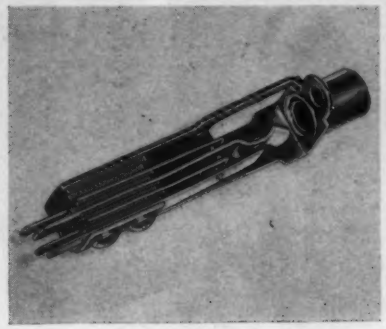

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NATIONAL UNION ELECTRONIC TUBES

Einthoven first described th string galvanometer in 1903, and i 1906 published the results of th first clinical studies.[3] Three lead or points of obtaining the potential were ordinarily used—between th two arms, between the left leg an the right arm, and between the lef leg and the left arm. The pea voltage so obtained is of the orde of one millivolt. It is interesting t note that Einthoven often had pair of wires over a mile lon between his patient and his record ing equipment. The amount of 6 cycle pickup which would be obtaine under these circumstances today ca easily be imagined.

By 1913 the use of the string galvanometer in recording the elec trocardiogram had spread to thi country, and became in a few years a highly useful clinical tool. The string galvanometer has an input resistance of about 3,000 ohms, and thus the potential recorded is to some extent dependent on skin re sistance. This difficulty is not pres ent in modern electrocardiographs which consist of mirror-type gal vanometers preceded by several stages of vacuum tube amplification Large coupling condensers must be used to reproduce the long slow in jury potentials obtained in coronary disease. For research involving po tentials obtained directly from the heart, direct-coupled amplifiers must be used, mainly in order to show shifting of the baseline.[3]

The general nature of the electro cardiogram and its changes in most of the diseases of the heart were rapidly determined empirically, but the fundamental basis of the electro cardiogram still remains comparatively unknown and a fertile ground for research. The situation was considerably obfuscated by the assumption of early experimenters that injuring a region of the heart made that region incapable of producing an action potential, and that it could thus be used as an "indifferent" electrode with respect to other regions of the heart. To anyone with the slightest practical knowledge of electricity this is manifestly absurd, because even if the region did not produce a potential it would act as a saline bridge to the surrounding uninjured muscle.

What actually happens is that there is a large prolonged positivity of the injured muscle with respect

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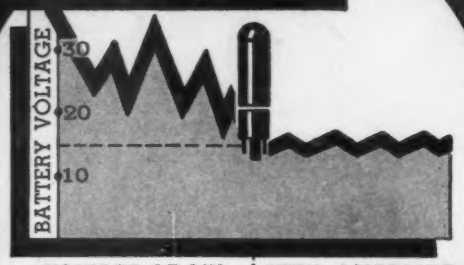

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to the uninjured muscle during contraction, as shown at the Wisconsin laboratories in 1938.[4] This would of course give a record indistinguishable from a negative change under the uninjured lead, and it was so interpreted erroneously by practically all investigators. This agreed with their preconceived idea that a negative state was synchronous with contraction of the cardiac muscle, and many present-day electro-physiologists have blindly accepted this classic dictum and interpreted their own results in the light of this supposed "fact".

The part of the heart which is beginning contraction is usually somewhere near zero potential, between a highly positive and highly negative area, and its potential is usually changing rapidly. Contraction may be preceded by either a positive or negative potential, and there are some parts of the heart which are never negative.

Many naive attempts have been made to explain the electrocardiogram as composed of two parts, an upstroke from one ventricle and a downstroke from the other. The electrocardiogram is, in fact, the result of a highly complex charge distribution on the surface of the heart, affecting the peripheral leads according to well defined laws of potential distribution in a volume conductor. It is to be hoped that in another decade enough will have been learned about the electrophysiology of the heart so that physiologists may propound intelligently a theory or theories explaining satisfactorily the phenomena observed.

Electronics in Study of Brain

A more recently developed clinical use of action potential recording is the electroencephalogram. It has been known for many years that when an impulse travels along a nerve, an action potential is produced. That such a potential is present in the brain was first shown by Caton, an Englishman, working on the cortex of rabbits in 1875. In 1924 Hans Berger successfully recorded and analyzed the potentials from the human brain, using needles extending through the scalp to the outer surface of the skull, and published his results in 1929. He later used electrodes on the surface of the

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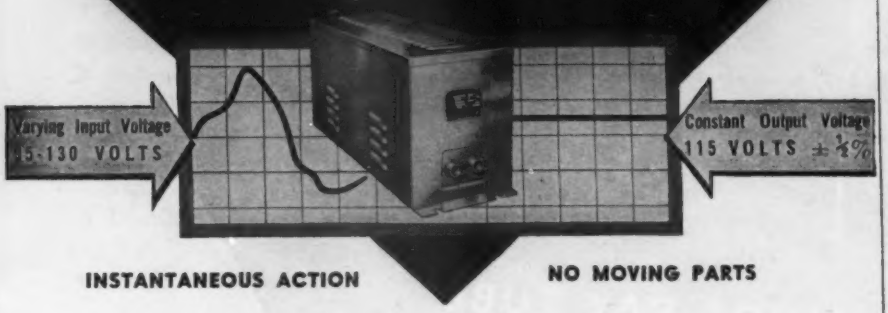

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scalp, which is now the metho generally employed. His analysi revealed that in the normal brai the output consisted of: (1) th alpha waves, frequency about 1 cps, and an amplitude of 25 to 15 microvolts, and (2) the beta waves frequency 15 to 60 cps, amplitude 1 to 15 microvolts. There are othe components, probably artefacts, with frequencies up to about 125 cps.

Various types of mechanical optical oscillographs were used b the early workers, being superseded by the cathode-ray oscillograph fo the most refined work, and by th ink-writing oscillograph developed by Tonnies. The ink writer has the advantage that an immediate and very cheap record is obtained which is extremely important be cause of the long records which must often be taken while waiting for an intermittently appearing abnormal ity to manifest itself. In abnormal conditions large slow waves are fre quently found, 1 to 6 cps, with an amplitude up to 300 microvolts. Such waves, and variants of them, are frequently found in various types of epilepsy and in brain tumors. In the latter case they appear to be caused by pressure on the cortex and may possibly be analogous to the injury potentials found under similar conditions in the heart.

It is interesting to note that the appearance of the normal alpha waves is possible only when the mind is moderately free from thought and when few optic stimuli are allowed to reach the brain. This circumstance is explained rather plausibly by the hypothesis that these slow waves are due to the automatic and synchronous dis charge of the cortical neurons, and that the rhythmic simultaneity of discharge is broken up by mental activity. This general principle has been used in the recently reported application of electroencephalography to lie detection.

From the above considerations it would appear that it would be necessary that the recording equipment have a frequency response from 3 to about 100 cps, but as a matter of fact the frequencies above 45 are of little importance from a diagnostic standpoint. This simplifies design problems, as the amplification of stray 60-cycle fields which will be picked up even in a screened room may be reduced considerably. Noise

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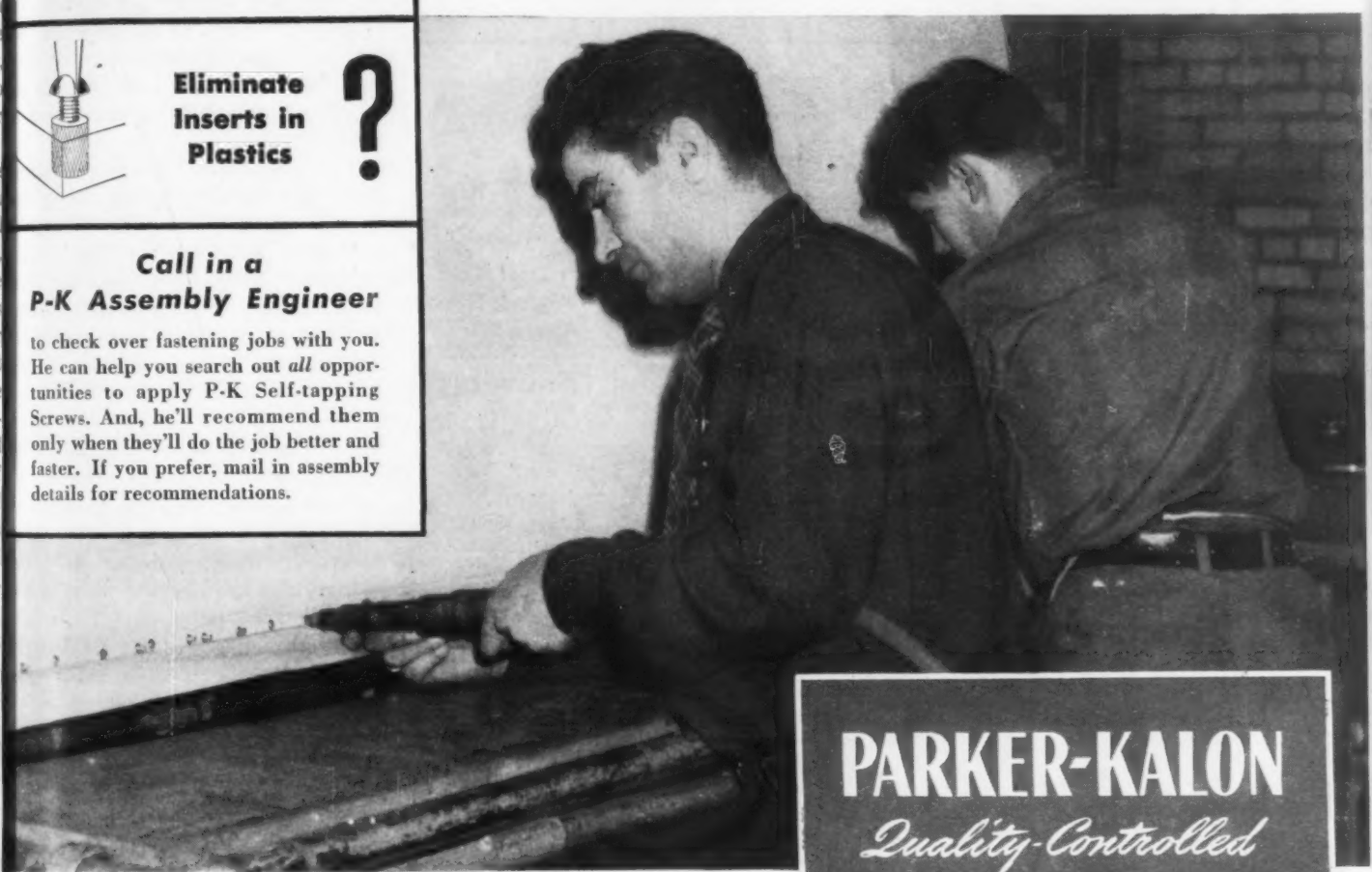

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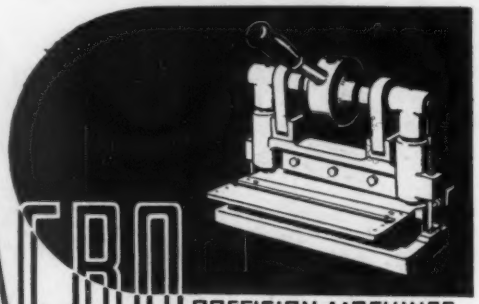

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(Illustrated)

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from thermal agitation in resist and shot noises in tubes is spre over the audio frequency range, a cutting off all but a band from 3 to cycles is highly effective in reduci noise. This is especially importa because of the extremely low pote tials which must be amplified, nece sitating a noise level of about microvolts or less.

Other Medical Applications

Besides the applications discusse electronics is used in practical med cine in other ways too numerous f detailed discussion. Ultraviolet ra are used for the irradiation of mi and other substances to produc vitamin D, for the sterilization o air, and for the treatment and pre vention of disease. Several minin companies are trying irradiation o their workers as they leave th mines, traveling on a moving be under mercury vapor lamps.

A very familiar device is the hear ing aid, the most recent of which con sists of a crystal microphone wit a three-stage vacuum tube amplifie feeding into a crystal earphone es pecially designed to fit into the ear A more complete discussion of hear ing aid design may be found in a article which appeared previously i this journal.[5]

One of the most widely publicize electronic devices which have ap peared recently is the Berma Moorhead metal locator, for use i removing shrapnel and similar ma terial from the tissues. Afte further clinical trial and modifica tion of the instrument, it shoul prove to be a device of great valu to the military surgeon. Details o this device are not as yet availabl to the public.

A tremendous number of elec tronic devices are used in medica research, among which are th electron microscope, stimulators,[6] pH meters,[7] colorimeters, etc. A re cently developed device measure continuously the oxygen saturatio of arterial blood in man, by send ing a beam of colored light throug the ear to a photocell.[8] Other de vices of possible interest are an apparatus for recording systoli blood pressure,[9] and an electronic de vice for testing fatigue by the flicker fusion method.[10] In previous issues of ELECTRONICS I have described an automatic blood pres

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Post-war retrenchments, expansions and projections will require a new scheme of things—new economies, greater diversifications, etc. The complete engineering facilities of Electronic Enterprises are available to you for collaboration on your problems. Inquiries invited.

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sure recorder (May 1942), an oscilloscope (Dec. 1941), a delayed sweep circuit (March 1942), a photoelectric membrane manometer, an electronic relay, a precedence indicator, and a photoelectric myograph (Jan. 1943).

The end of the war will result in the publication of many electronic devices which are now military secrets. The war has done much to stimulate development of apparatus for the study of military physiology, but has to some extent impeded fundamental research. The application of this newly developed apparatus to basic problems should, however, solve many instrumental difficulties which previously impeded the experimentalist.

REFERENCES

(1) Morgan, Russel H., *Am. J. Roentgenology and Radium Therapy*, **48**:220–228, 1942.
(2) Einthoven, W., *Arch. Intern. Physiol. Liege*, **4**:132–164, 1906.
(3) Goldberg, H., *Am. Inst. El. Eng.*, **59**: 60–64, 1940.
(4) Eyster, J. A. E., Meek, W. J., Goldberg, H., and Gilson, W. E., *Am. J. Physiol.* **123**:717–728, 1938.
(5) Kamen, Ira: Hearing Aid Design, ELECTRONICS, July 1942.
(6) Goldberg, H., ELECTRONICS, Aug. 1941.
(7) Cenco-Gilson a.c.-operated pH meter.
(8) Millikan, G. A., *Rev. Sci. Inst.* **13**: 434–444, 1942.
(9) Omberg, A. C., *Rev. Sci. Inst.* **7**:33–34, 1936.
(10) Henry, Franklin, *J. Exp. Psych.* **31**: 538–543, 1942.
(11) Hertzman, Alrick, B.: A Photoelectric Plethysmograph, *Am. J. Physiol.* **124**: 328–340, 1938.
(12) Lilly, John C.: The Electrical Capacitance Diaphragm Manometer, *Rev. Sci. Inst.* **13**:34–37, 1942.

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The world's most powerful x-ray tube for the treatment of cancer has been installed in a cancer research and treatment center in Los Angeles. It has been designed to carry on the research which was conducted at the California Institute of Technology by Dr. Seeley Mudd and Dr. Clyde K. Emery from 1930 to 1938 with the first 1,000,000-volt x-ray. Shown here is the control desk for the tube, of 2,000,000 volts, and four other less powerful tubes. The control desk has a two-way communication system which can be plugged into the treatment rooms

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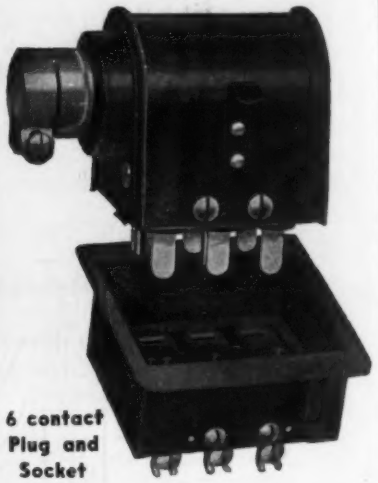

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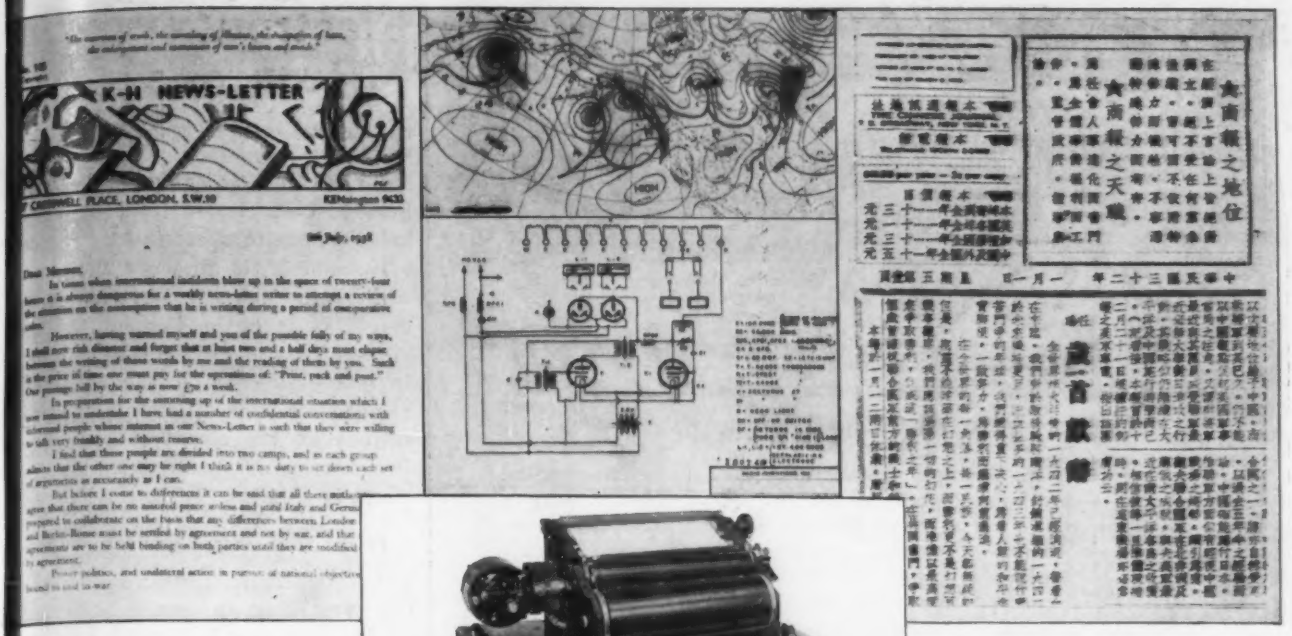

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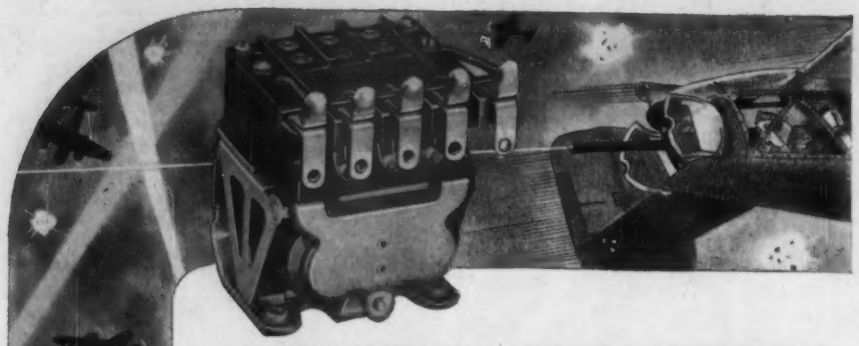

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Electron Microscope

(*Continued from page* 147)

scope, interests metallurgists greatly. Serious obstacles to its use in this field have been overcome by the development of the replica technique in which an extremely thin plastic mould is made of the surface and viewed in the electron microscope. In one year this technique has developed into one of the major applications of the electron microscope. Its extreme importance in the war effort is obvious.

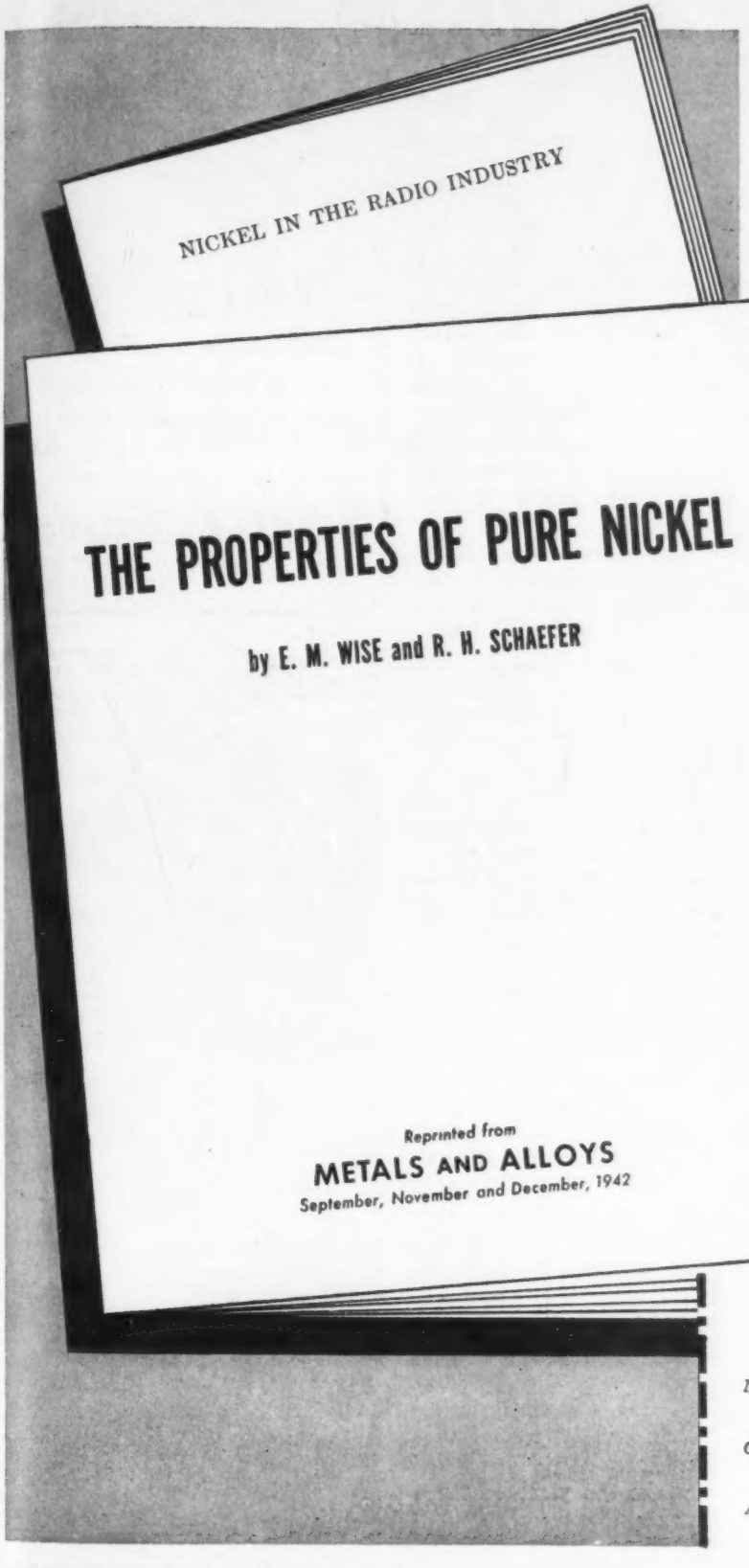
Future Microscopes and Future Uses

As electrical lenses are improved the resolving power of electron microscopes may be extended to 1000 times that afforded by the light microscope, still further extending the vision of the research workers. Atoms and molecules and the more intimate structures of large molecules and viruses will all become visible. The transition between the realms of living and non-living will be put under close observation. The gap between the elemental building blocks of matter, studied so carefully by the indirect methods of physics and chemistry, and the gross structures of every day life will then be completely filled.

The trend of future development of the electron microscope itself is also becoming apparent. The present overloading of all the instruments already in use indicates the need for a much wider distribution in the future. On the other hand the complexity and cost of the present apparatus is an important hindrance to such a wide distribution. With this in mind, the electron microscope has already undergone a complete redevelopment that has resulted in successful instruments much smaller and simpler in structure than previous instruments. This has been done by sacrificing versatility, convenience and the possibility of modernization of installed instruments and not by sacrificing performance. This new development should greatly increase the number of electron microscopes available and hence add to their value, simply as a result of the more rapid accumulation and distribution of the information which they give.

For the Creators of the New World of Electronics

—a new booklet which provides engineers and physicists with a convenient summary of the fundamental properties of nickel


NICKEL IN THE RADIO INDUSTRY
THE PROPERTIES OF PURE NICKEL
by E. M. WISE and R. H. SCHAEFER
Reprinted from
METALS AND ALLOYS
September, November and December, 1942

"The Properties of Pure Nickel," illustrated here, is a new booklet reprinted from a three-part article just published in "Metals and Alloys."

It supplements the previous publication entitled "Nickel in the Radio Industry."

Together these two publications provide engineers in the electronic field with the latest summary of information and data on nickel. They also include an extensive bibliography for use when a more detailed investigation of particular properties is required.

"The Properties of Pure Nickel" covers the physical, mechanical, electrical and other properties and constants of (1) very pure nickel, and (2) commercially pure "A" Nickel; it discusses (3) the effects produced by alloy additions of some other elements to low-carbon nickel made from commercial electrolytic nickel. The International Nickel Company, 67 Wall Street, New York, N. Y.

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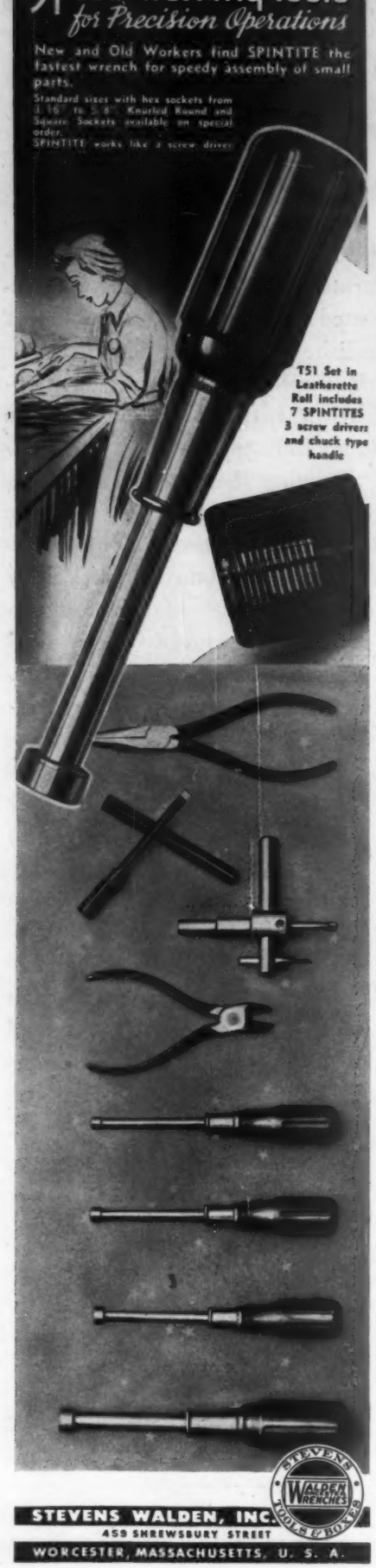
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Tomorrow

(*Continued from page* 155)

able to believe that the cathode-ray tube may form a nucleus for some new and unforeseen developments, probably in connection with the ultrahigh frequencies. At best, however, these will probably come slowly at the start.

Electronic Calculators. In the past few years, personal living as well as business procedures seem to have become involved in a multitude of new uses of printed forms, tabulations, and miscellaneous paper work. The time is ripe for machinery and appliances to simplify this expansion in the requirements for routine hand work. One can be very sure that once this subject is successfully attacked for one application, its use will spread rapidly and it is also almost certain that electron tubes and their circuits will be somewhere in the picture.

Other Possibilities. The routine clerical details attending such simple procedures as a purchase in a department store, the buying of a railroad ticket, the sorting and distribution of mail, and payroll accounting, as well as a host of other routine clerical operations, will readily come to mind. The routine drudgery and exasperating delays associated with such procedures are certain to be a great stimulus to their simplification, minimizing, or elimination. The principle of scanning that is used in television may very well find application in some other field such, for instance, as photoelectric methods to enable the blind to read a printed page. Industry as well as the entertainment field may obviously use television principles.

The important thing to be kept in mind in all of our plans for the future is the stern necessity of having each electronic development economically sound from a fundamental viewpoint.

New devices must be pieces of equipment that people are willing to buy and to use on the basis of what they will do better or faster or easier or cheaper than non-electronic equipment. No amount of "glamour" will cover up or take the place of these two fundamentals.

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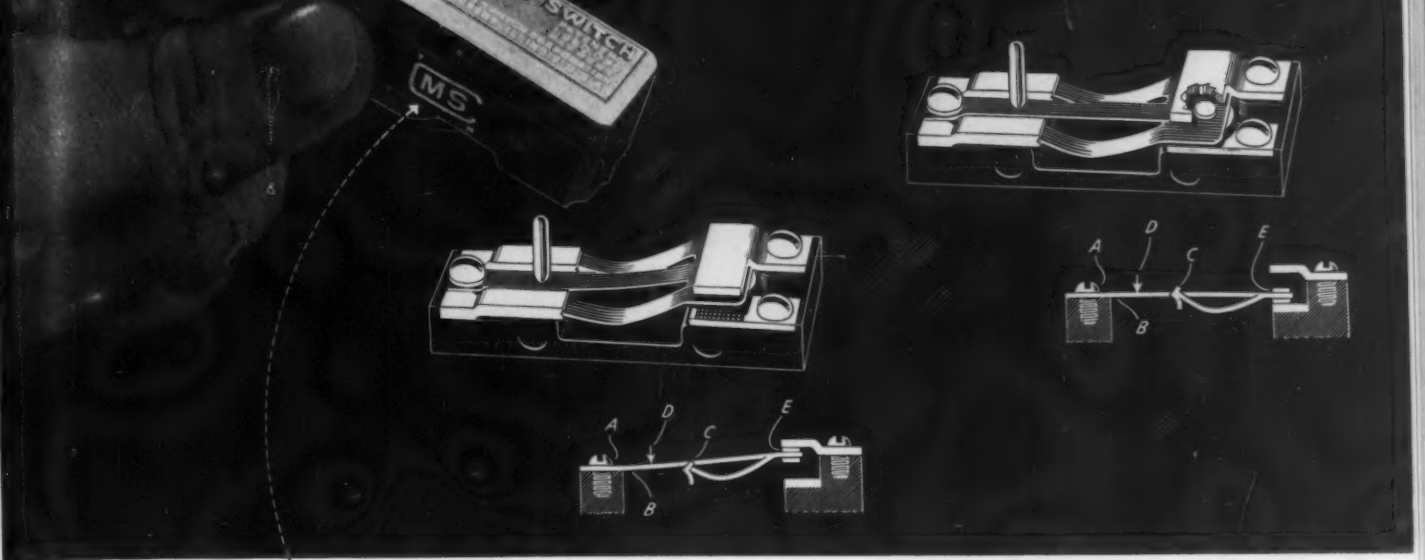


Without This Mark MS It Isn't a Micro Switch

There is only one micro switch—the MICRO SWITCH—manufactured by this company. When you buy a precision snap-action switch, it is not a MICRO SWITCH unless it has the now familiar trademark shown on the side of the switch as illustrated above.

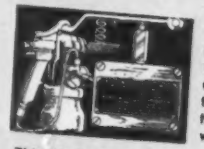
The MICRO SWITCH is thumb-size, feather-light, and operates precisely at the same point for millions of operations with lightning-fast contact action. It is accurately built to exact standards from precisely made parts. Its performance characteristics can be changed to meet functional requirements. It can be furnished with many types of actuating mechanisms and protective housings.

The MICRO SWITCH is the only precision snap-action switch available to you which employs the principles of design illustrated above and described below.

The MICRO SWITCH principle is different. It involves no reverse bends—no buckling "oilcan" action. The long member of the one piece, three bladed, beryllium copper leaf spring "B" is supported in cantilever at "A". The two short members are curved in compression to rest in the notches at "C." These two strut-like springs exert an upward force to hold the electrical contacts "E" together with a force of 40 to 100 grams, depending on the type of switch. The operating force applied at "D" deflects the longer tension member downward in a gentle curve until the upward force of the bowed members is overcome and the contact end of the spring moves downward with the sharp, snap-action which makes clean cut electrical switching. The distance the contacts are separated is controlled to suit the particular problem at hand, and may be as much as .070 inches for high altitude aircraft use. Removal of the force at "D" allows equally fast snap-return to the original position... The electrical contact moves in the same direction as the operating force. This direct action not only provides accurate performance, time after time, for millions of operations, but should there be a welding or sticking of contacts due to overload, the direct-acting force acts as insurance to break the weld and to put the switch back into service.

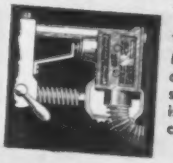
On present or future designs it will pay you to consider the many advantages in space saving, accuracy, precision performance, and the dependability of a snap-action switch. But when you do, be sure that you select a MICRO SWITCH for the reasons enumerated above. Shown below are typical applications, and the two catalogs illustrated in the lower left hand corner of these pages will be highly advantageous to you in incorporating the MICRO SWITCH into your design.

How and For What Micro Switches Are Used



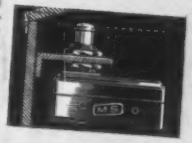
This shows an explosion proof Micro Switch used with a spray gun which automatically cuts out the entire operation of the spraying booth when the gun is shut off.

This illustration shows the Micro Switch with a spring leaf actuator serving as a break indicator as used in textile mills or paper mills.



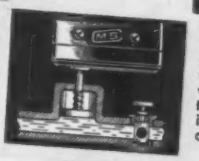
This illustration shows Micro Switch enclosed a die cast housing with synthetic rubber seal, a is being used as a lath carriage stop.

This illustration shows a Micro Switch with a pushbutton actuator being used as a safety switch in a high tension cabinet door. It is a normally open switch in which the circuit is opened as the door is opened.



This illustration shows two steel enclosed Micro Switches which serve as overrun limit switches on a machine tool.

This illustration shows the use of two Micro Switches with spring type plungers to insure safe positioning of material in a punch press or a similar tool.



This illustration shows use of a Micro Switch with a spring plunger which is actuated by the pressure of a liquid in a line as the actuating medium.

SEND FOR THESE CATALOGS

Your up-to-the-minute engineers will thank you for keeping them informed about the Micro Switch. Send for as many of the Handbook-Catalogs illustrated here as you think necessary. No. 60 covers Micro Switches in general; and No. 70 deals with specific Micro Switches for use in aircraft.

Switch is a trade name indicating manufacture by Micro Switch Corporation

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Such details as: (1) the square shoulder on the mounting stud of the post which seats in the slot in the plate so as to prevent annoying loosening of the posts when operating the clamping head; (2) the telescoping boss and socket so as to permit the plates to grip tightly the thinnest chassis as well as the thickest panels without necessity of grinding or filing; (3) the availability of the plates in Steatite, Mica filled natural bakelite, as well as standard black phenolic; are but three of the "Designed for Application" features that make this terminal set more desirable to use than others.

JAMES MILLEN MFG. CO., INC.

MAIN OFFICE AND FACTORY
MALDEN
MASSACHUSETTS

Wire Telegraphy

(*Continued from page* 166)

the problem of attaining a duplex balance.

In addition to the high-quality metallic telegraph circuit just described, a grounded telegraph circuit commonly known as a "gimplex" is operated over the same pair of wires. The pair of wires in the metallic loop circuit is bridged at each end of the line with a center-tapped 3000 ohm resistor. The center-tapped point is connected to a regular grounded duplex telegraph set. To improve transmission each half of the 3000-ohm resistor is shunted by a 4 microfarad capacitor. The derived ground-return telegraph circuit thus obtained is slightly inferior to an ordinary grounded telegraph circuit.

Postal Telegraph has a large number of metallic circuits in regular operation. A typical example would be one of the New York-Chicago circuits. This is a 3-channel multiplex circuit. Repeaters are located at Elmira, N. Y., Meadville, Pa., and at Fostoria, Ohio in the order named. When the circuit was operated single-wire with ground return the repeater at Meadville was of the rotary regenerative type. After the circuit was made fully metallic it was possible to dispense with the rotary repeater and replace it with the simpler non-regenerative repeater. A recent check-up of operating margins on this circuit at a speed of 61 words per minute per channel after a routine lineup showed a loss of only one percent in signal length distortion (non-duplex) after passing through the three repeaters and four line sections. The accumulative signal distortion caused by irregularities in the duplex balance was four percent. The total signal distortion was only five percent which is remarkably small when compared to earth-return operation. It is likely that six-channel equipment, not at present available, could be satisfactorily operated over these circuits.

The foregoing is a brief description of the part played by vacuum tubes in the Postal Telegraph System. Particular emphasis has been placed on the new metallic telegraph system in which tubes play a vital part.

It is felt that only the surface has been scratched, in utilizing vacuum tubes in wire telegraph systems and the future will show an ever increasing use of electronic devices.

TELEPHONE TUBES—Characteristic vacuum tubes employed by the Bell System. Those on the left have the same physical form as tubes used during the last war (VT-2); those on the right represent more recent structures

Wherever man goes•••after the war he will encounter the two-way radiotelephone! Thanks to the science of electronics, this amazing medium of communication will find many more useful applications in the business, industrial, governmental and social life of all countries. At the moment, Jefferson-Travis equipment, with its many exclusive developments, is being used by United Nations throughout the world. With peace, it will be yours to know and enjoy—*thanks to electronics!*

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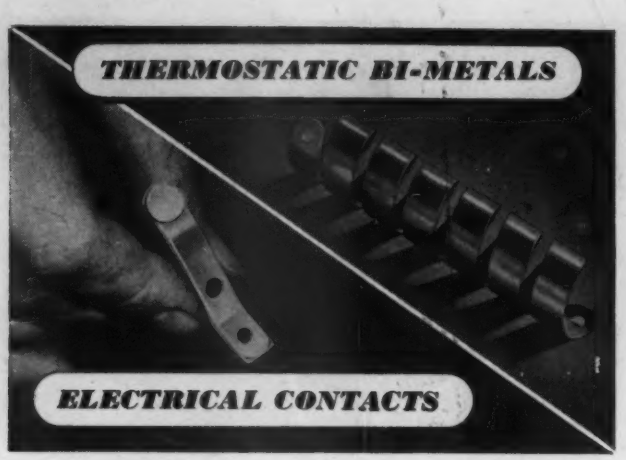

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Behavior of Wave Guides

(*Continued from page* 80)

for much greater convenience.

Circular guides have advantages and disadvantages in practical use, but their principle of operation is the same as that of the rectangular guide: the metal wall must always hold electric charge to terminate the electric field, or carry current to serve as boundary for the magnetic field, or both. In no other guide, however, is it as easy to recognize component plane waves as in the guide of rectangular cross section, and that is why most of this article has been devoted to rectangular guides. Almost all that has been said, however, can be extended to guides of other shape.

A circular guide with a simple wave pattern is shown in Fig. 8. It is easy to see that this is similar to the wave of Fig. 6. Indeed, if a wave of this type passed from a circular guide into a rectangular guide, through a proper transition section, it would travel on down the rectangular guide.

Two-Surface Guides

There are two fundamental kinds of guides with metal walls: those consisting of only one continuous metal surface, like the rectangular and circular guides we have been discussing, and those consisting of two separate metal surfaces. A concentric transmission line is of the latter type. So is a parallel-wire transmission line. So is a twisted pair of wires. So is any other electric circuit, if one wishes to make the most of this point of view.

Conductors Only Provide Boundaries. From the wave-guide point of view, the conductors in any circuit exist for the sole purpose of serving as boundaries to the electric and magnetic fields. This may seem an extreme view to take of the fifty feet of bell wire between your front door and your kitchen, yet it is the magnetic field in the transformer that provides the energy, the electric and magnetic fields about the wires that carry the energy, and the magnetic field in the box on the kitchen wall that rings the bell. There is, of course, a flow of current in the wires,

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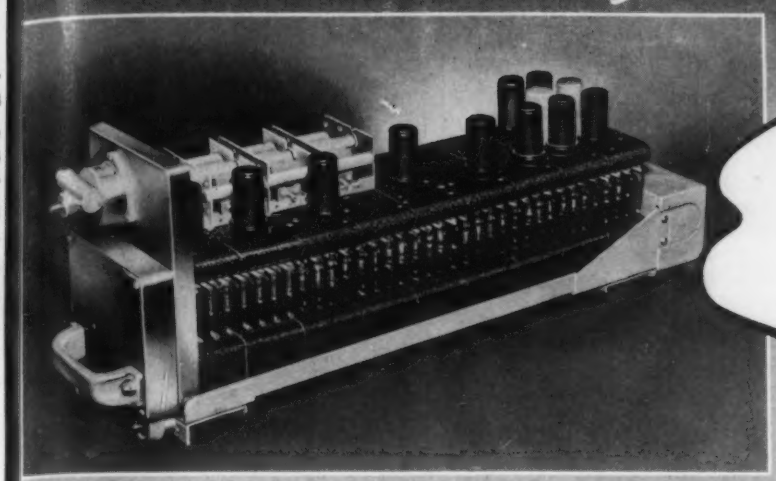

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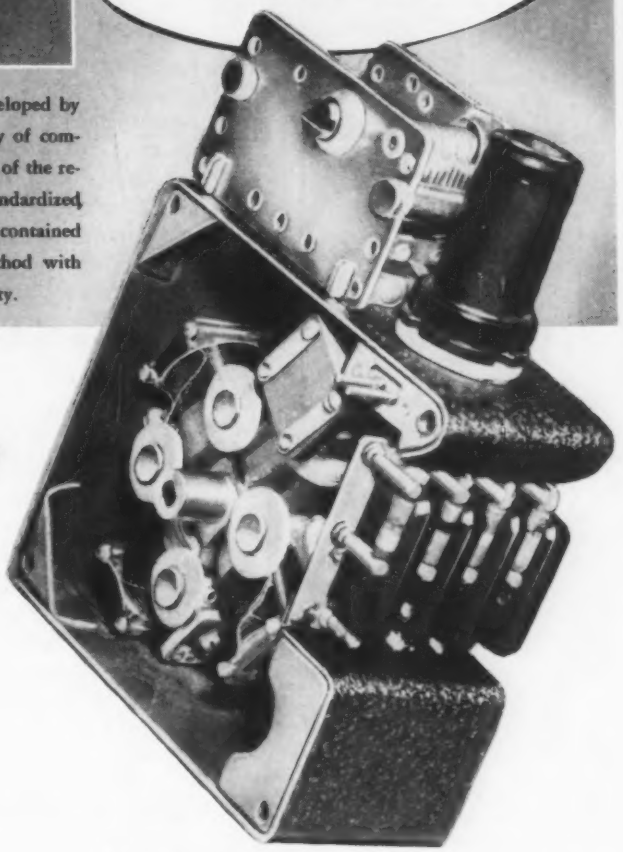

Cell-unit construction creates *new standards* in radio performance

The R. F. Amplifier cell, shown at the right, is typical of Harvey "Unitized" construction. The standardized case supports the variable tuning condenser and a remote cut-off high-mu pentode tube. The rotary turret coil assembly is mounted on a hollow trunnion, and the R. F. transformers are rotated by a band change control, which connects the desired coil to the fixed components of the circuit.

L C ratios of the R. F. circuit are greatly improved by the Harvey turret coil which provides up to 40% less minimum circuit capacitance than is found with conventional band switch methods. The exceptionally high Q of Harvey R. F. circuits is due to coil design and use of low-loss coil forms, minimum contact resistance between a coil and the circuit through use of solid silver contactors provided with wiping action, and efficient shielding. Such features assure performance from Harvey multi-band receivers equal to the finest single-band receivers with comparable tuning ranges.

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Write for descriptive data on Harvey Communication Receivers. Cells to meet specific requirements are available to other manufacturers for use with their products.

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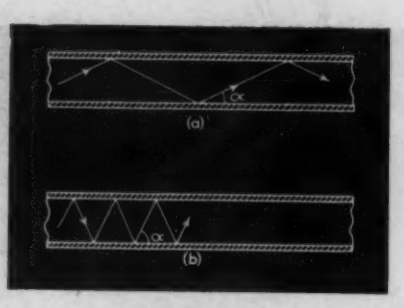


Fig. 7—The speed at which a wave travels through a wave guide depends upon the path which the wave takes, and this in turn depends upon the width of the guide and the frequency of the wave. At (a) the speed will be relatively high since there are few reflections in a given length of wave guide. At (b) there are more reflections per unit length, and the speed is correspondingly decreased

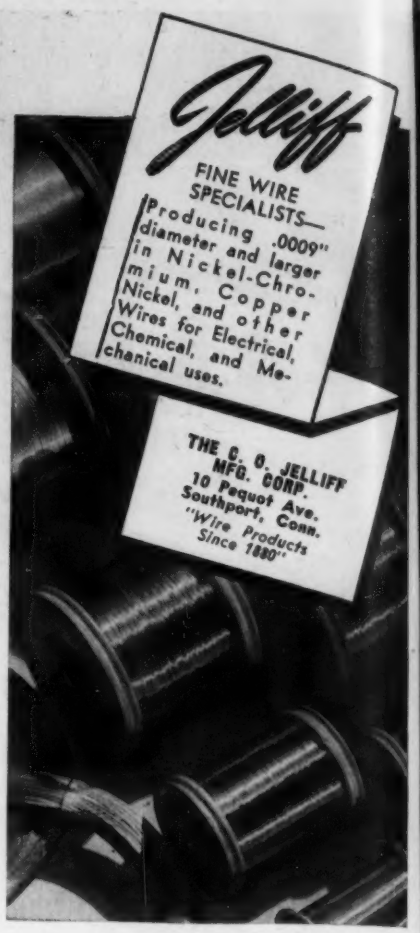
but that is merely incidental and neither wires nor current serve any useful purpose except to guide the electromagnetic fields into the little box in the kitchen. It is freely admitted that this concept would not be of much service to the electric repair man, but it is absolutely necessary for the ultra-high-frequency engineer.

Wave Guides Can be Curved

A hollow wave guide can be used to carry a wave from one place to another as a speaking-tube carries sound. Although we have spoken of straight guides, a guide may be curved if the bends are not too sharp. There are practical applications for such guides only at very high frequencies, for unless the wavelength is of the order of magnitude of a few centimeters the wave guide must be prohibitively large.

Hollow vs. Concentric Guides. Even with centimeter waves the hollow guide must meet the competition of the concentric line. The outstanding advantage of the hollow guide is that it requires no insulation, while a concentric line must necessarily have the inner conductor supported by some solid material; there is appreciable loss of energy in even the best of insulators in an ultra-high-frequency field, and in an extreme case the strong electric field near the small inner conductor of a concentric line may cause dielectric breakdown of the insulating material, or of the air itself.

The most suitable type of transmission line or wave guide to use for a particular application depends on many factors, and most particu-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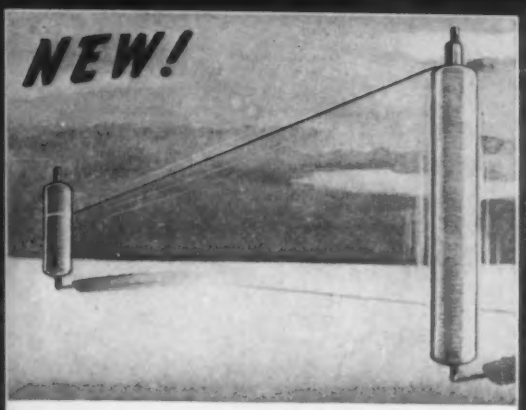

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1,000	2.5-2.6	.0001-.0002
1,000,000	2.5-2.7	.0001-.0004

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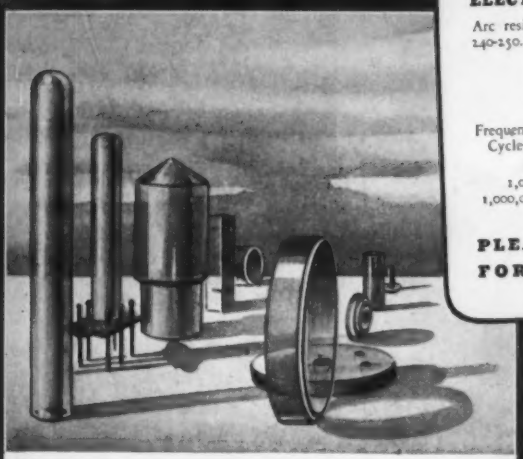

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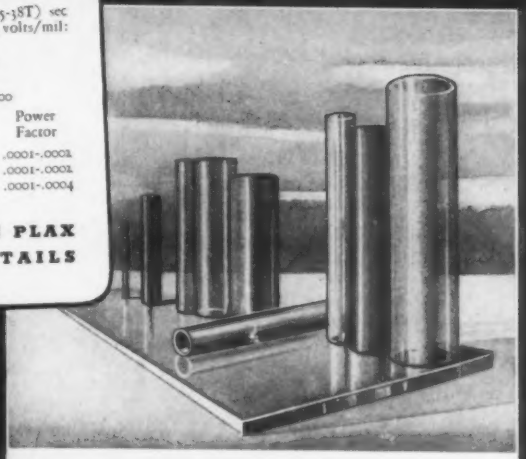

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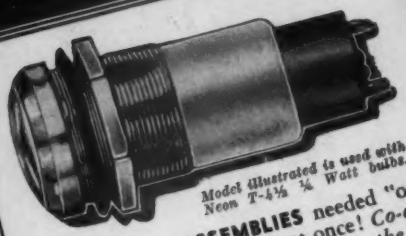

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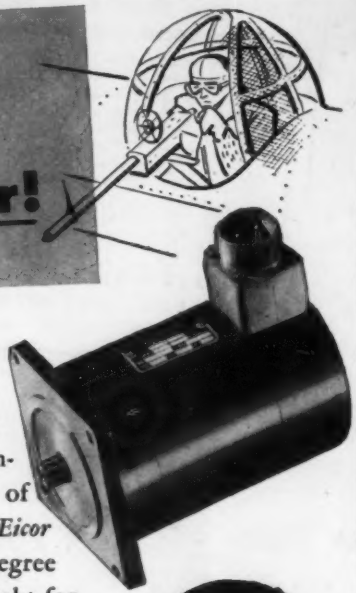

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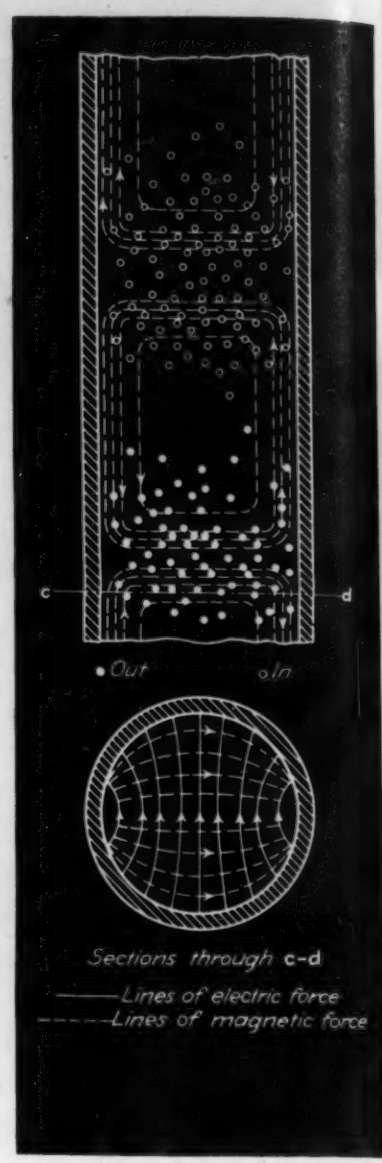

Fig. 8—Plan and cross-section views of the electric and magnetic fields in a circular wave guide for one mode of oscillation

larly on the frequency. Hollow guides are at their best at the highest frequencies.

Hollow guides are also very valuable as resonators. Cut off a section of the guide of Fig. 6, or the guide of Fig. 8, and close each end with a flat plate of metal. The result will be an *electromagnetic cavity resonator*. If a wave guide is like a speaking-tube, a resonator is like an organ pipe. A standing wave may be produced inside it by repeated reflections, back and forth from end to end, at one specific frequency. There can also be other modes of electromagnetic standing waves in a cavity resonator, with various patterns of the electric and magnetic fields. In one of the most usual modes the elec-

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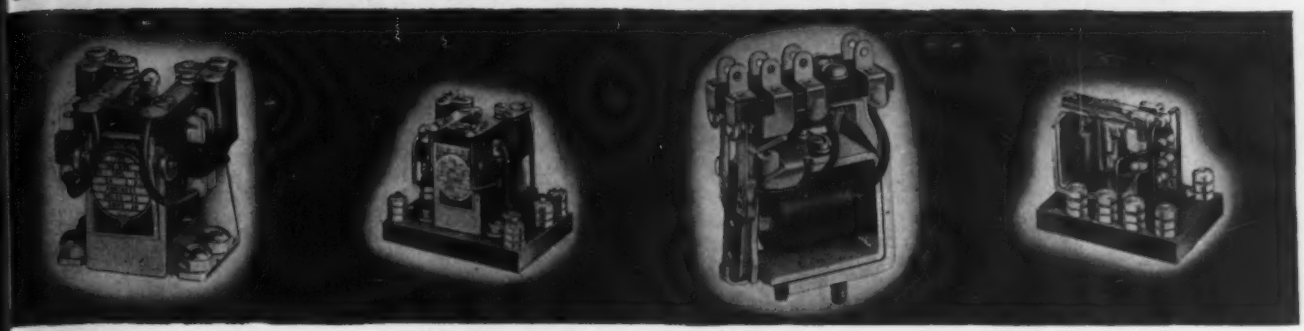
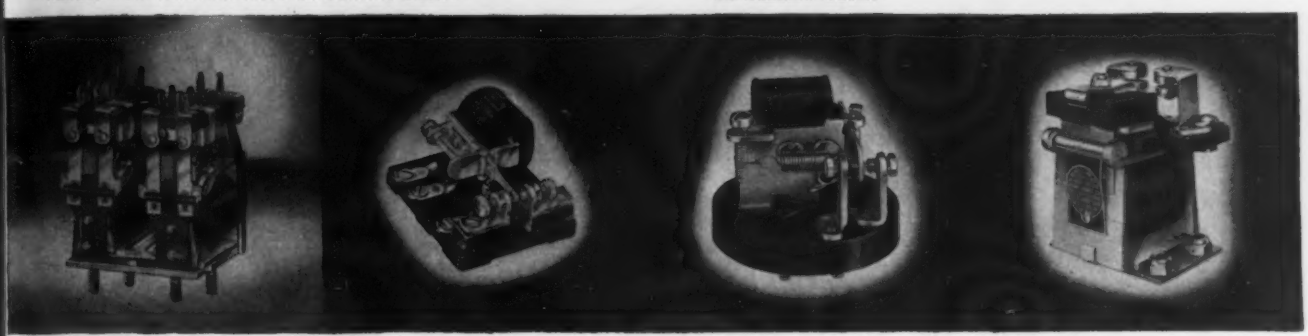


BO *a compactly designed 2½ watt relay, rated 15 amperes at 24 volts DC or 110 volts AC, standard is double pole double throw and also made in 3 and 4 pole double throw — (model BOB when mounted on Bakelite Base).*

BJ *a small compactly designed 2 watt relay, rated 5 amperes at 24 volts DC or 110 volts AC, standard is double pole double throw — (model BJB when mounted on Bakelite Base).*

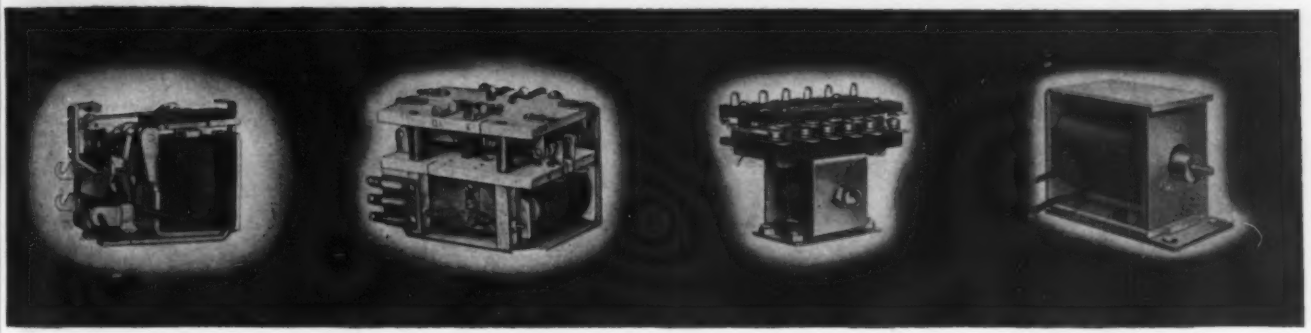


BJU *a latching relay for aircraft; maximum rating 5 amperes per contact, non-inductive.*

B *a sensitive relay operating at 0.012 watts*

G *a sensitive relay operating at 0.05 watts*

AN *a power relay handling up to 75 amperes at 24 volts DC*



AR *a featherweight relay with 5 ampere contacts and weighing 50 grams*

AK *a high speed Keying Relay, 20 cycles per second . . Contact rating 1000 volts at 30,000 ft . 20 megacycles . . 4 pole double throw*

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tric field extends from one flat side to the other of a chamber shaped like a tin can.

Resonant Characteristics. A resonator serves the same purpose at ultra-high frequency as a tuned circuit at moderate radio frequency, and does it better. It is more highly resonant, more able to discriminate frequency, and has higher Q than the best of tuned circuits. It is rather analogous to a half-wavelength of concentric transmission line used as a resonant circuit. A resonator, or a pair of resonators, may be built in as part of an ultra-high frequency vacuum tube, as in the Klystron; the resonators then serve instead of tuned circuits to determine the frequency generated.

Solid dielectric Guides

Another possible type of wave guide is not made of metal but of dielectric material. Instead of being a copper pipe it may be a solid rod of, let us say, glass. Reflection of electromagnetic waves takes place from a surface between glass and air. Light, for example, is reflected at such a surface, and may be totally reflected if attempting to pass too obliquely from glass into air.

Somewhat similarly, if an electromagnetic wave of sufficiently high frequency is sent into the end of a dielectric rod it will be guided to the other end of the rod because of its inability to leave the dielectric material. The practical difficulty with such a wave guide is that all dielectric materials have high energy loss in a high-frequency electric field, and the propagated wave is attenuated too rapidly. In other words, all dielectric material is somewhat opaque at ultra-high frequency.

Starting the Wave

There is no doubt about how to start a wave on a two-wire transmission line, or even a concentric line. Connections are merely made to its two terminals. But it is by no means obvious how a wave is to be started traveling along a hollow-pipe guide. One cannot make connections to its two terminals because it does not have two terminals. So the usual expedient is to use a small antenna within the wave guide, and simply radiate waves down the pipe.

The shape of the little antenna is selected to suit the type of wave to

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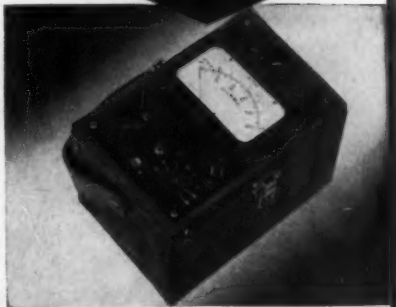

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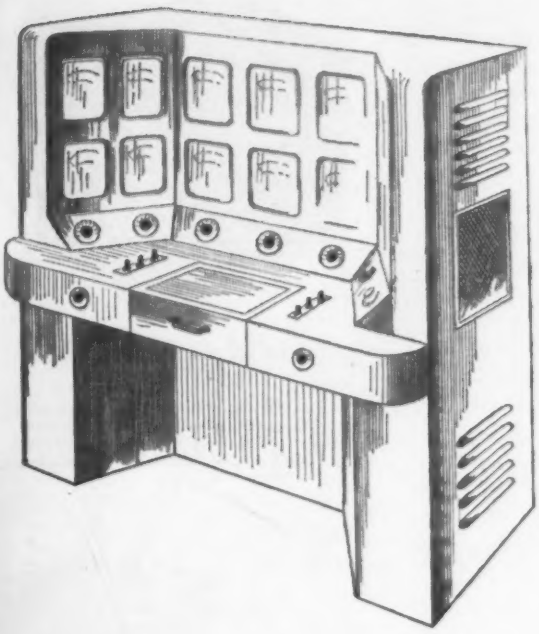

For military reasons the test set shown is not a new development.

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Bombarders
Oscillation Aging
Static Aging
Static Characteristic Test
Oscillation Characteristic Test
Noise Test
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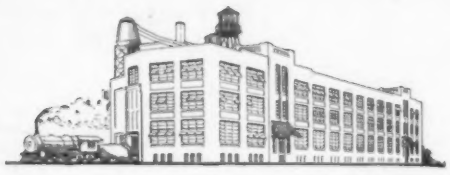

Engineering, Design, Development and Manufacture of Radio and Allied Communications and Test Equipment. Development of Electronic Controls and Measuring Devices.

ELECTRONIC DIVISION

SHERRON METALLIC CORPORATION

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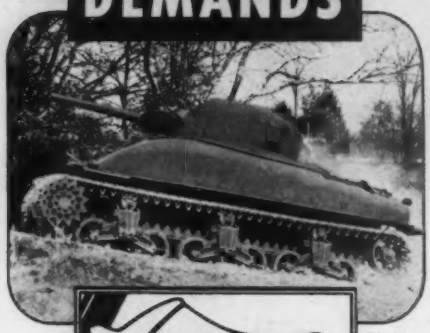

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be propagated. For instance, in the guide of Fig. 6 the antenna could be a short, straight rod projecting in through one of the walls of the guide and parallel to the lines of electric flux. The electric and magnetic fields around such an antenna would roughly approximate those of the wave that is propagated along the guide. At least, the magnetic field would be similar to that desired, and the electric field of the antenna would have its principal component parallel to the electric field of the desired wave.

An inserted rod antenna would produce complicated disturbances in the wave guide, but the guide is able to carry only certain relatively simple types of waves. As a result all the undesired components of the fields about the antenna would fail to propagate, and only the proper kind of wave would go on down the guide. It is probably desired to transmit only one way along the guide from the antenna, so a short distance upstream from the antenna the pipe would be closed with a flat metal plate. By properly adjusting the distance from the antenna to the reflecting metal plate the closed end of the guide may be made to act somewhat as a resonator and the strength of the transmitted wave will be enhanced.

To obtain other wave patterns within the guide, other types of antennas are used. A small loop may be used for some purposes, and for others an axial rod is used instead of a transverse rod.

Terminations

At the other end of the guide, energy is received on an antenna similar to the transmitting antenna. If an antenna is good for transmitting, it is equally good for receiving. From the receiving antenna energy may be carried by two wires, or, better, by a concentric line, to wherever it is to be used or detected.

If, however, the energy is to be radiated into space as a free radio wave it may simply be allowed to pass outward from the opend end of the wave guide. This is a possible means of radiating, but not a good one, for the wave guide is not well matched to open space and the wave cannot get out freely.

Radiation is greatly improved if the end of the guide is belled out as in a horn. Then the larger the horn,

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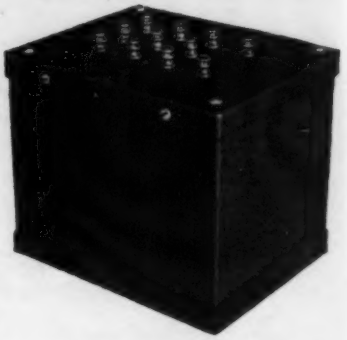

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Acme case designs require minimum mounting area. May be mounted on bottom, or suspended from top or side. Produced to specifications in sizes from 50 VA to 500 VA.

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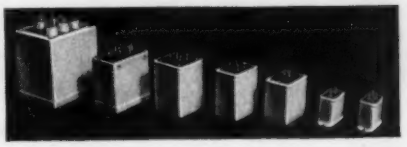
Type T-7025 Acme Filament Tranformer for 2—866 Rectifier Tubes. Requires minimum mounting space; mounting centers for 25 VA, only 3" x 3½", height 3¾. Precision-made to specifications in production quantities in ratings from 25 VA to 1½ KVA.



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Acme compound-filled, sealed case Audio, Driver, Interstage transformers, Reactors and Microphone input transformers are built to withstand and satisfactorily perform under extreme temperature variations. Bulletin 159 tells why. Write for your copy today.

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TRANSFORMERS

He'd be wearing an "E" pin too . . . if he were home

They gave him a gun and taught him how to shoot it. No need to tell him *why!* He's an Adlake man—one of many Adams & Westlake employees in the armed forces of our country. As such, he needs no prompting to play the vital role to which a threatened nation has assigned him.

If he were home today, he, too, would proudly wear an Army-Navy "E" pin. For his former fellow workers—men, women, and management of The Adams & Westlake Company—have recently won the Army-Navy Production Award "for high achievement in the production of materials of war." They, too, need no prompting in the accomplishment of their assigned tasks!

We of Adlake look upon the "E" pins we wear—and upon the Army-Navy "E" pennant which floats above our plant—as a challenge to strive still harder to hasten Victory. We know that every Adlake man in uniform is doing his dead-level best. We, his friends at home, will not let him down!

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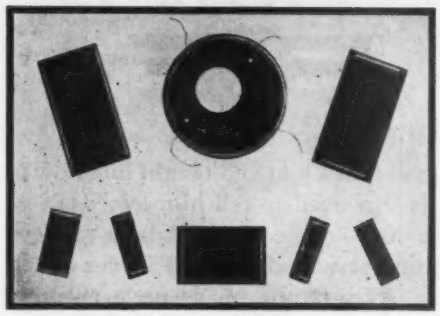

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the more efficient the radiation; the horn acts as a megaphone. A large horn on the end of a hollow guide produces a highly directive beam of radiation, and the wider the mouth of the horn the sharper the beam that it radiates. It is one of the great advantages of centimeter waves that they are easily directed by a horn, by a parabolic reflector, or by various other directional devices.

REFERENCES

(1) Chu, L. S., and Barrow, W. L., Electromagnetic Waves in Hollow Metal Tubes of Rectangular Cross-Section, *Proc. I. R. E.*, p. 1520, **26**, No. 12, Dec. 1938.

(2) Southworth, G. C., Hyper-frequency Wave Guides—General Considerations and Experimental Results, *Bell System Technical Jour.*, p. 284, **15**, No. 2, April 1936. Diagram courtesy *Electrical Engineering*.

BIBLIOGRAPHY

Slater, J. C., "Microwave Transmission" (McGraw-Hill, 1942), Chapter III—Rectangular Guides.

Stratton, J. A., "Electromagnetic Theory" (McGraw-Hill, 1941), pages 537–545—Waves in Hollow Pipes.

Lindman, E. F., Propagation of Electric Waves Through a Metallic Tube and Between Two Parallel Metallic Plates; abstract. *Wireless Engineering*, p. 467–8, 19, Oct. 1942.

Kemp, John, Electromagnetic Waves in Metal Tubes of Rectangular Cross-Section, *Jour. Inst. E. E.*, p. 213–8, **88**, No. 3, Sept. 1941.

Clavier, A. G., and Altovsky, V., Experimental Researches on the Propagation of Electromagnetic Waves in Dielectric (cylindrical) Guides, *Electrical Communication*, p. 81, **18**, 1939.

Clavier, A. G., Theoretical Relationships of Dielectric Guides (cylindrical) and Coaxial Cables, *Electrical Communication*, p. 276, **17**, 1939.

Barrow, W. L., and Greene, F. M., Rectagular Hollow-pipe Radiators, *Proc. I. R. E.*, p. 1498, **26**, No. 12, Dec. 1938.

Schelkunoff, S. A., Transmission Theory of Plane Electromagnetic Waves, *Proc. I. R. E.*, p. 1457, **25**, No. 11, Nov. 1937.

Page, L., and Adams, N. I., Electromagnetic Waves in Conducting Tubes, *Physical Review*, p. 647, **52**, No. 6, Sept. 15, 1937.

Barrow, W. L., Transmission of Electromagnetic Waves in Hollow Tubes, *Proc. I. R. E.*, p. 1298, **24**, No. 10, Oct. 1936.

Carson, J. R., Mead, S. P., and Schelkunoff, S. A., Hyper-frequency Wave Guides—Mathematical Theory, *Bell System Tech. Jour.*, p. 310, **15**, No. 2, April 1936.

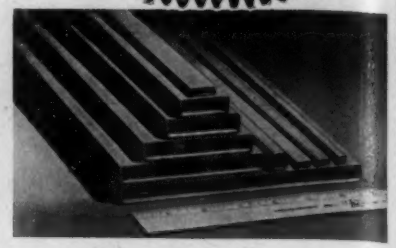
See also the above references.

• • •

TEST FLIGHT RECORDER

New radio test flight recorder perfected by engineers of the Vultee Aircraft Corp., checks all reactions of an airplane during its test flight and radios them to recording devices on the ground. Harvey Giffen, (center) the inventor, and his assistants are shown at the Vultee plant checking the progress of a new fighting plane in flight 100 miles from the laboratory

PARAMOUNT



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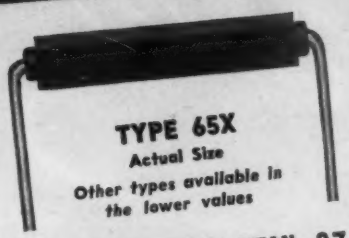

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I.R.E.-AIEE War Conference

(*Continued from page* 157)

members from London by shortwave radio circuit. The technical difficulties under which broadcasting service is maintained in Great Britain under conditions of actual bombing and of air raid alarms were outlined in this address.

Through the facilities of the Columbia Broadcasting System, a nationwide radio network linked the New York meeting with the I.R.E. Section banquet held simultaneously at Washington D. C., in which L. P. Wheeler and A. F. Van Dyck took part. A feature of this broadcast was an address by James Lawrence Fly, chairman of the Board of War Communications and of the Federal Communications Commission.

Increasing Tube Life

On Wednesday afternoon a conference on "Getting the Most Out of Electronic Tubes in Wartime" was led by D. W. Jenks, E. E. Spitzer, C. C. Herskind, G. H. Rockwood, and S. B. Ingram.

Not only the tube designer, but the equipment designer and tube user have a responsibility in obtaining maximum tube life. Much effort is spent by manufacturers to assure long life, but this can be achieved only if tube is used in accordance with the manufacturer's instructions. The user is the loser if these instructions go unheeded. Maintaining filament voltage at specified values, and providing adequate cooling, with filters when forced draft is used are the greatest aids to prolonging tube life. Mercury vapor tubes should be handled in such a manner that splashing of mercury is avoided. If tubes are water cooled, the water supply should be analyzed to ascertain that no harmful ingredients are present. The water supply should be filtered.

In certain cases possible "salvage" operations may extend the life of the tube, but increased emission by raising the filament voltage or reactivation should be employed only as a last resort. It was shown that life may be lengthened by operating tubes below normal filament voltage during short periods of stand-by operation instead of turning them off.

The morning technical session was opened by Otto H. Schade who

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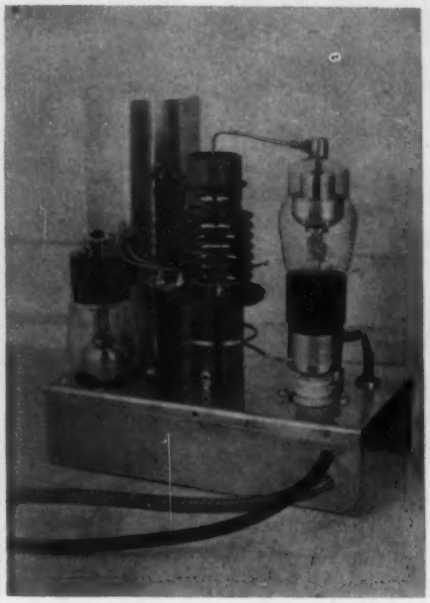
spoke on "Radio-Frequency-Operated High-Voltage Supplies for Cathode-ray Tubes." The operation of such tubes requires a power source providing high potential direct current ratings from 1 to 30 kilovolts or perhaps higher, but the current requirements are seldom in excess of one or two milliamperes. Suitable power supplies in the past have customarily been obtained through the use of high-voltage transformers operating from a 60-cycle power line, used in conjunction with suitable rectifiers and filtering circuits. Such practice requires comparatively bulky equipment and is potentially if not actually, dangerous to personnel since the power capabilities of



High voltage high frequency power supply for cathode-ray tubes, described by Mr. Schade

such a system usually exceed those required by the cathode-ray tube. The use of high-frequency power sources instead of the 60-cycle power line permits a substantial reduction in size and weight of the component parts of the power supply system. In addition the limited input power, generated by vacuum tube oscillators, permits the construction of relatively safe power supplies when the current requirements are low.

Mr. Schade described several types of high-voltage power supplies in which power was obtained from an oscillator operating at a frequency of approximately 100 kilocycles. One of the power supplies developed 1,000 volts at 0.3 milliampere. A larger supply developed from 10,000 to 12,-

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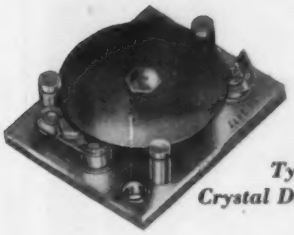
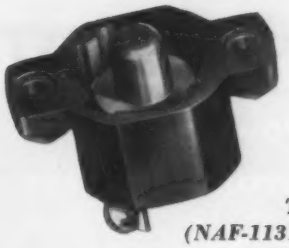


Type B3120
Crystal Dew Point Control



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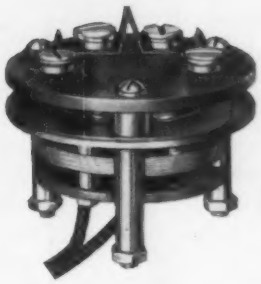
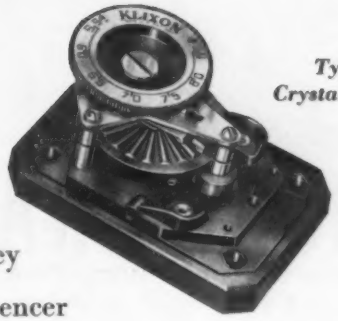


Type ER Series
Ambient Compensated Time Delayed Relays



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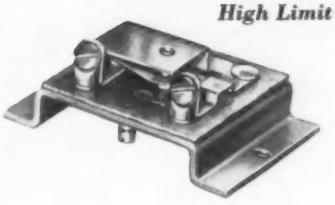

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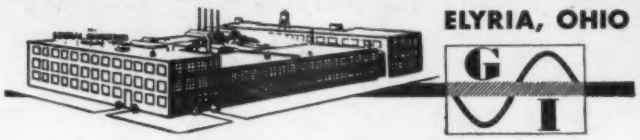

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000 volts at approximately double the current.

For obtaining high efficiency, the tuned r-f step-up transformer windings must have high impedance and a low power factor. They should likewise have a minimum capacitance to ground. When used in a self-oscillating circuit, primary and secondary tuned circuits must be overcoupled to obtain efficient energy transfer. The circuit has then a double coupled tuning characteristic requiring that the oscillator frequency be stabilized at one of the peaks by feedback from the secondary winding. The radio frequency transformer from which the high frequency output was obtained consisted of a grid coil of 70 turns, and a plate coil of 55 turns. Interposed between the two coils was the high voltage winding of 1,400 turns divided into a number of pie sections in order to reduce distributed capacitance. All three windings were reasonably well coupled together and were wound on a coil form approximately 1½ inches in diameter. In order that losses in the coil form at high frequency may be reduced to a minimum, losses were reduced through the use of extremely high quality dielectric tubing, from which sections of the tubing, not required for mechanical rigidity, were cut. The output of the high-voltage winding is fed to any of the conventional rectifier circuits. Because of the high frequency involved, only a simple filter is required to obtain satisfactorily constant direct current and voltage. Where high voltages are required, voltage doubling circuits are employed.

Power loss is proportional to the capacitance of the high-voltage circuit which is to be minimized by suitable design. The design of optimum high-voltage winding with low self-capacitance and maximum impedance is, therefore, of great importance and governs the operating frequency of the particular unit.

The physical construction and electrical performance of several developmental high-voltage supplies were discussed and illustrated. It was clearly demonstrated that one of the difficulties with such a high-voltage supply is that of corona discharges which result from excessive voltage gradient. To obviate these difficulties, sharp points or corners are to be avoided. One way of ac-

Is this the beginning of a miracle?

Mr. Ernest G. Enck, our technical director, thinks we should put greater emphasis in our advertising on our sizing and beneficiation of ores and minerals. We do, he emphatically reminds us, prepare a significant list of chemicals from these ores and minerals.

There are, for instance, the carbonates and chlorides of lithium and strontium; the nitrates of lithium, yttrium, caesium, thallium and zirconium; and the benzoate, chloride, hydroxide, fluoride, and stearate of lithium . . . to mention only a few. A better understanding of these underemployed chemicals is already producing startling discoveries.

Lithium stearate is a case in point. Lithium stearate or "metal soap", was just what petroleum researchers needed to compound for our fighting planes *one* grease which tames the biting cold of Reykjavik as easily as it does the scorching heat of Tunisia. Will the automobile industry look into the post-war possibilities of this Foote patented product? Probably! Another example is strontium. Strontium salts, now vital to the war effort, are intriguing the interest of ceramic engineers and, after the war, may well influence the making of whiteware, glazes, lustres and optical glasses.

Yet, this is only a beginning. Much of our most interesting exploratory work is still quietly bubbling within the retorts of our laboratory. Today or tomorrow it is just possible we may help you achieve another miracle of chemistry, or to start one. If you suspect we can help you now, please write us.

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You are, of course, well acquainted with zirconium metal powder and its advantages for vacuum tubes. Ductile zirconium, like the powder, is an active "getter" at elevated temperatures. However, ductile zirconium is doubly useful, since — because of its structural strength — it may be shaped into vacuum tube elements. In fact, the metal may be spot-welded, butt-welded or machined. Experimental quantities are available as wire, sheet, rod, and woven screen. Other special forms can be made on request. Your inquiries are invited.

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A WORD ABOUT DELIVERIES

Naturally deliveries are subject to necessary priority regulations. We urge prompt filing of orders for delivery as expeditiously as may be consistent with America's War effort.

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complishing this in practice is to use conductor tubes of appreciable diameter rather than wires of small size. To keep the voltage gradient to a suitably low value, a wire diameter of at least 10 mills for every 1,000 volts is desirable.

"Transmission-Line Charts" was the title of an interesting talk delivered by R. S. Julian, and illustrated with slides. Since the analytical approach to transmission line problems is usually rather tedious, time-consuming and unwieldy, recourse can be made, with considerable advantage, to the use of transmission line charts. A wide variety of charts has been devised for determining the voltage and current distribution along transmission lines or for determining the peak and power in the line. These charts may take any one of a wide variety of graphical forms, but all represent essentially the same data. The differences in the various types of charts result from the selection of the most convenient, coordinate axis, and this in turn, depends largely upon the type of problem to be solved.

It was shown that all of the characteristics of a transmission line could be plotted on a spherical surface. The various transmission line charts customarily employed in engineering work may then be obtained by suitable projection on to a plane surface from the various coordinate grid systems plotted on the spherical surface. The problem is analogous to that of drawing a plane map of the world; the various projections being given by various methods of projection whose utility is best suited to a particular purpose.

The very extensive use which Mr. Julian made of graphical methods and three dimensional models illustrating the various types of projection, make it impossible to do a very adequate job of reporting his paper. This is the type of paper which can be appreciated only by visual examination of the illustrative material presented. But Mr. Julian has made a big stride forward in showing the relationship between the various types of transmission charts, in indicating the maximum sphere of utility for the various types, and in outlining the manner in which one is related to another.

Polydirectional microphones, consisting of a single ribbon, the back of which is coupled to a damped

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U-H-F
TECHNIQUE

TWICE Electronics has reprinted "U-H-F Technique," a series of papers as follows: "Electrical Concepts at Extremely High Frequencies," "Radiating Systems and Wave Propagation," "Generators for U-H-F Waves," "U-H-F Reception and Receivers," "Wide Band Amplifiers and Frequency Multiplication," "Measurements in the U-H-F Spectrum," "Applications of Cathode-Ray Tubes," "Wave Form Circuits for Cathode-Ray Tubes." Stock is running low, and because of paper shortage we do not wish to reprint unless there is sufficient demand. This is a 64-page book—price 50¢ single copies, or 35¢ each for 26 copies or more. Readers are requested to tell us the number of copies of this widely-used symposium on u-h-f they are likely to need during 1943.

P.S. An abbreviated edition of this "U-H-F Technique reprint containing the articles "Electrical Concepts at Extremely High Frequencies," "Applications of Cathode-Ray Tubes," and "Wave Form Circuits for Cathode-Ray Tubes" (in two parts) are available at 25¢ each, post free.

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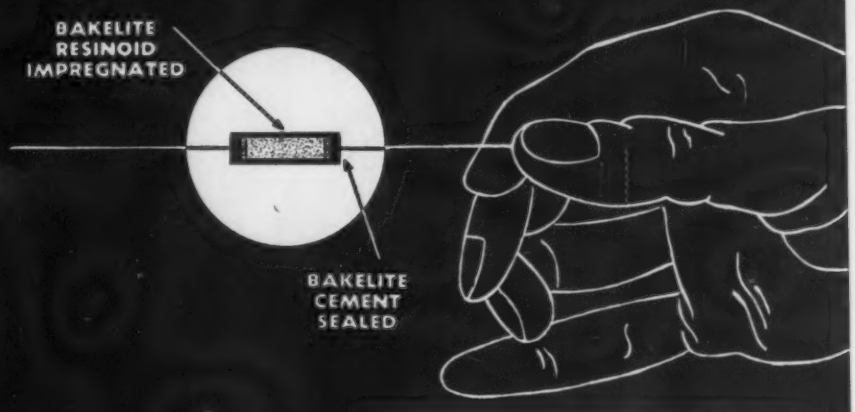
Smallest CAPACITOR .... *Yet* MOISTUREPROOF



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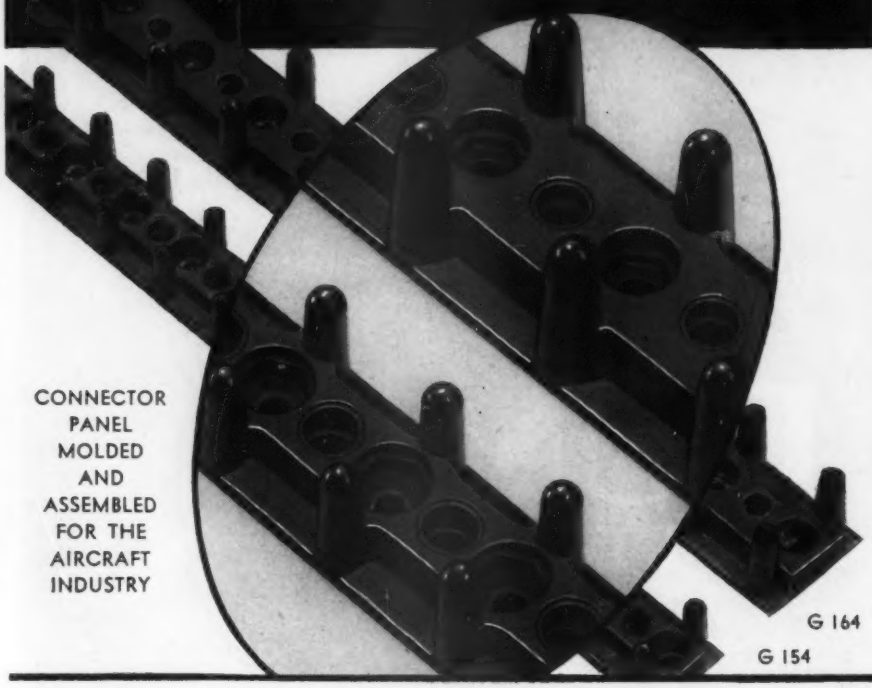

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G 164
G 154

folded pipe, and an inertia in the form of an aperture was described by H. F. Olson in a talk on "Polydirectional Microphones." Dr. Olson's paper was primarily a report of progress which has been made in the development of directional microphones within the last few years and up to our entrance into the war. several directional characteristics of the microphones described have been made possible through the use of improved magnetic materials which made possible a considerable reduction in size with consequent reduction of diffraction effects at high frequency.

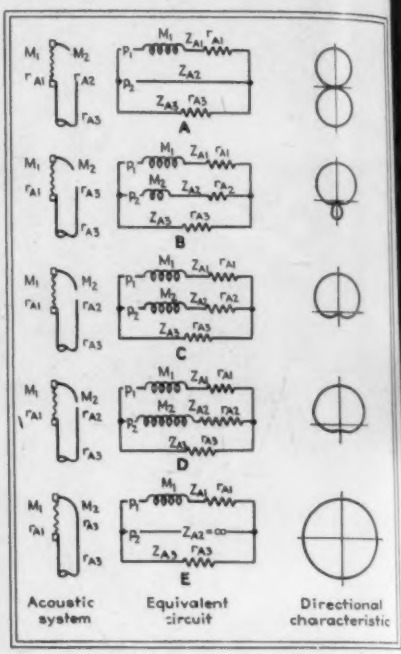
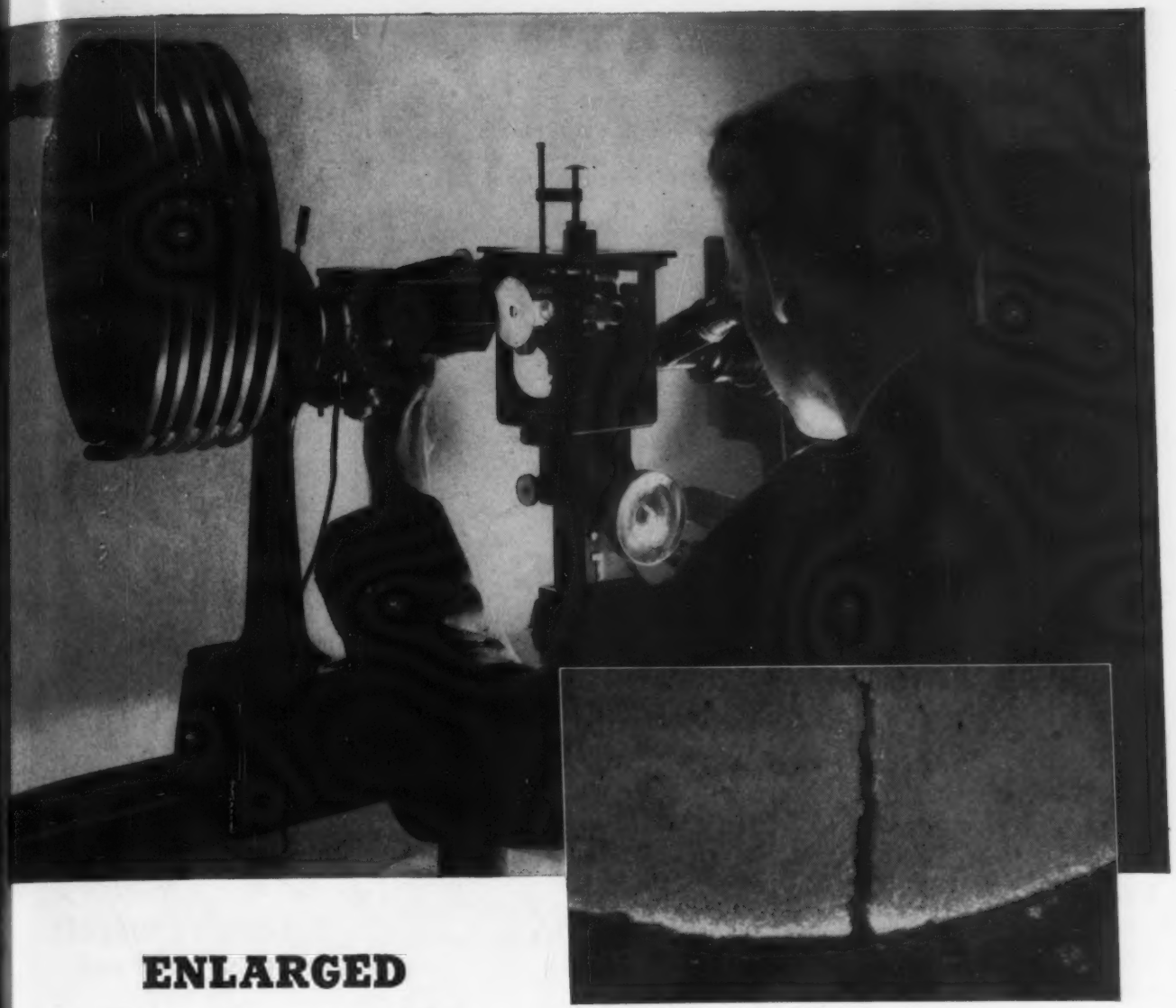


Diagram of directional microphone (left) with equivalent circuit (center) and pattern of directivity (right) discussed by Mr. Olson

The development of the directional microphone was carried out largely through an analysis of the equivalent acoustical circuit, shown for several directional characteristics, on the attached diagram. This procedure illustrates the increasing use of acoustic networks for solving acoustic problems of vibrating systems. From the practical point of view, the advantage of these microphones lies in the fact that a single infinity of directional characteristics, ranging from bidirectional, through all variations of unidirectional to non-directional, may be obtained simply by varying the size of the aperture in the back of the microphone.



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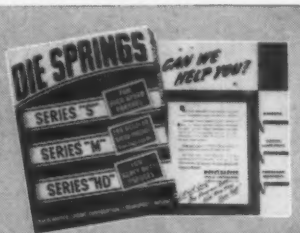

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H. W. Leverenz spoke on "Phosphors and the Periodic System of the Elements." By way of introduction it was stated that luminous materials or phosphors, may be classified as fluorescent materials or phosphorous materials. A fluorescent material is one providing an output of radiant energy only so long as it is excited by radiant energy falling upon the luminescent material. As shown in the accompanying illustration the rise and decay characteristics are practically instantaneous with the application and removal of the excitation. On the other hand, phosphorescent materials show a decided lag in the energy output after excitation is applied or removed. This characteristic results in the emission of light from the phosphorous material for several seconds and in some cases even for several minutes after the removal of the ultraviolet light or other excitation. In the demonstration it was shown that whereas ultraviolet light is usually the most effective radiation for exciting luminescent materials, then the effectiveness of the luminous material depends to a large extent upon the wavelength of the incident radiation. This is not the case when luminescent materials are excited by cathode-rays, since such rays excite all frequencies.

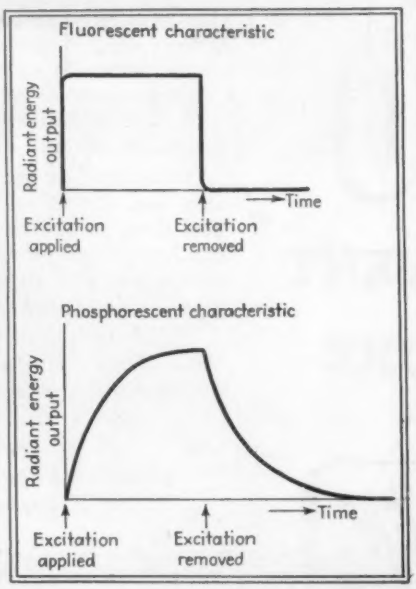

Diagram illustrating the differences between fluorescent materials (above) and phosphorescent materials

It has been suggested that the fluorescent and phosphorescent characteristics of various phosphors

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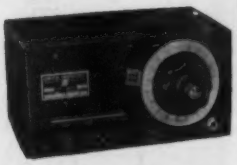

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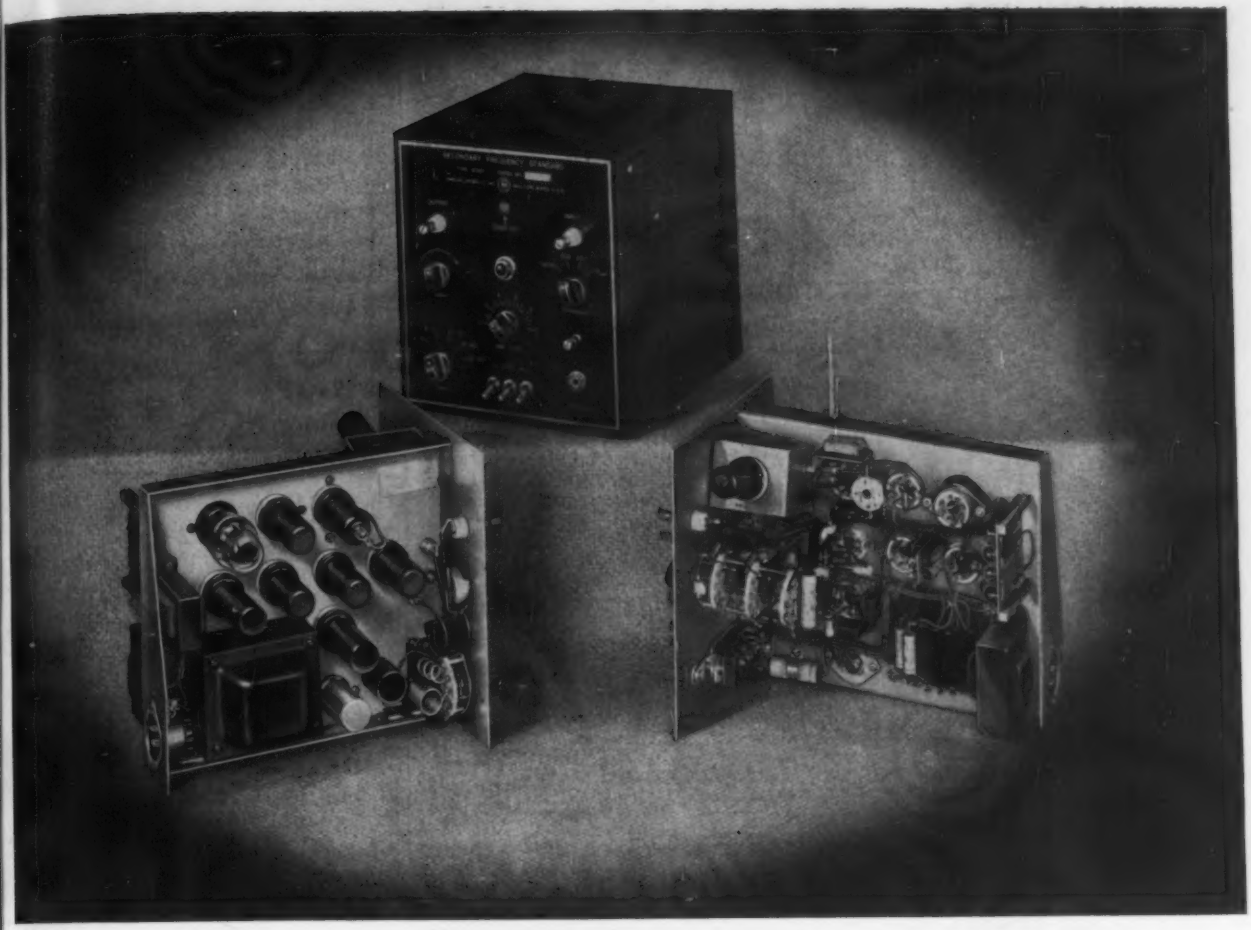

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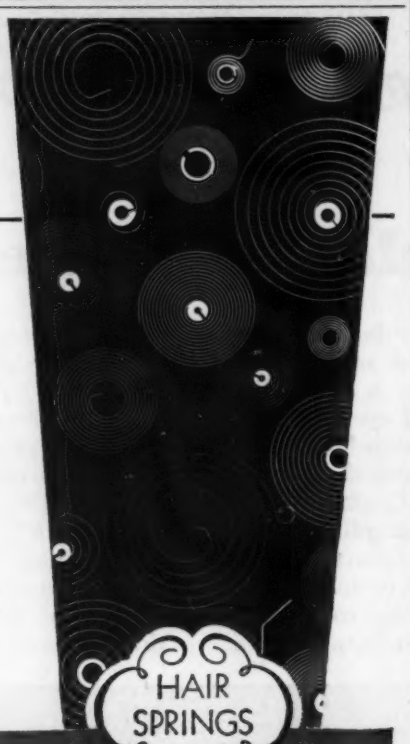

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Certain applications of lumine
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also for obtaining dramatic effect
and as a means of illumination wer
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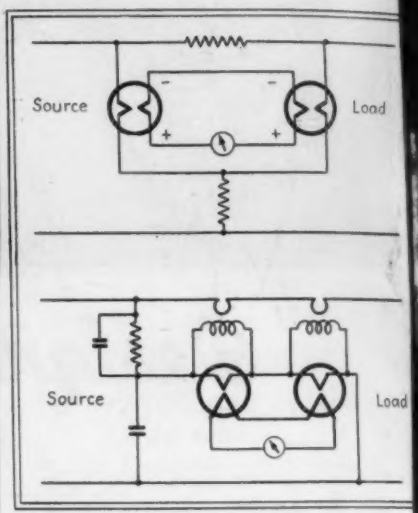
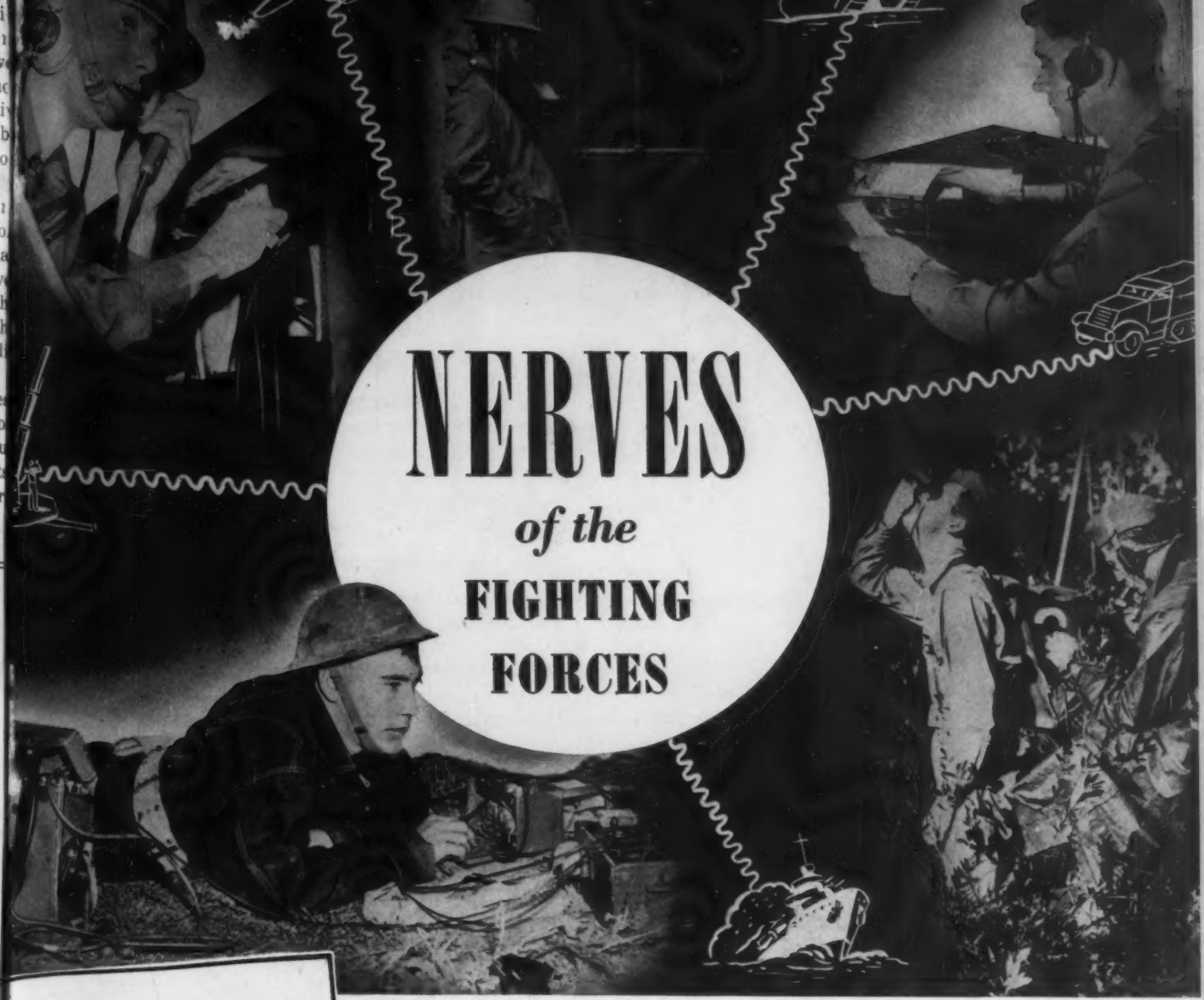


Schematic diagram of basic circuit for radio frequency wattmeter (above) with improved circuit employed in practice (below)

Not included in the initial announcement of the program was a paper by Brown, Epstein and Peterson, entitled "Direct Reading Wattmeters for Radio Frequencies" and delivered by Dr. G. H. Brown. The wattmeter described uses two thermocouples connected in voltage opposition so that the current read by the microammeter is the difference in current produced by the two thermocouples. The simple circuit shown in the attached diagram suffers from several defects which prevent it from being a commercially satisfactory instrument. The improved and modified circuit is also shown. It will be seen that voltages are induced across the heaters by means of air core transformers



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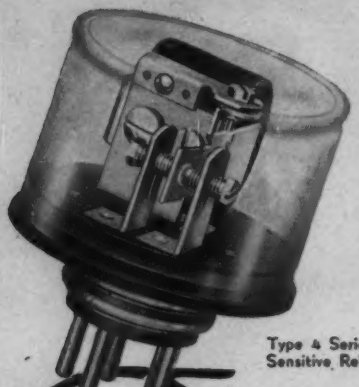

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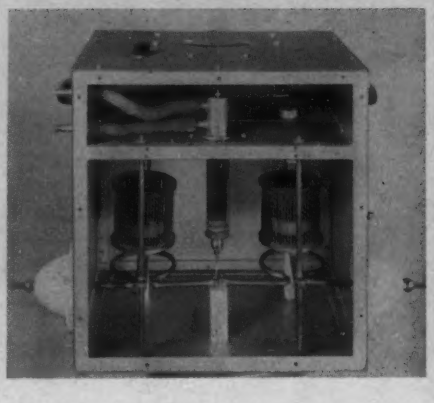

Photograph of the interior construction of the radio frequency wattmeter

rather than by means of a dropping resistor as in the first case. This materially reduces the voltage drop in the meter which is particularly important where high powers are involved.

Instruments using this basic design were illustrated and their use in high frequency broadcasting stations outlined. Wattmeters suitable for operation over a wide range of power factors and from frequencies from 200 to 2,000 kilocycles have been constructed.

Emphasis on Production

Following the business meeting in the afternoon, a number of papers, mostly devoted to production activities, were delivered, although one of these was a broad-gage address dealing with general developments in the communication field.

Lloyd Espenschied, in a paper "Electric Communications—the Past and Present Illuminate the Future," gave a rather unusual historical development and outlook concerning radio communication. It was shown that through the use of modern communication facilities based on the application of the electron tube, limitations of space or distance were greatly diminished. In attempting to hint at some of the possible developments of the future, Mr. Espenschied devoted a considerable portion of his talk to a discussion of the developments, on a frequency basis, of electrical communication during the past century. Manually-operated telegraphy required frequency bands of about 10 cps but this was extended to approximately 2,500 or 3,000 cycles with the invention of the telephone. Vast new frequency bands were opened with the discovery of electric oscillation

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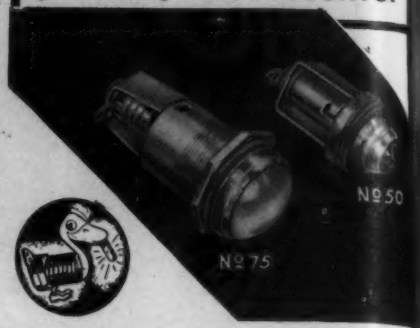

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Globar CERAMIC RESISTORS

Be sure your circuit actually requires close tolerance resistors before you specify them

CERAMIC or composition type resistors are not normally supplied as precision devices. Please, therefore, specify resistance tolerances as wide as possible in order that production facilities may be made to yield maximum quantities of acceptable resistors. To do otherwise, lowers production and slows up deliveries and wastes critical materials.

Production facilities for Globar Brand Ceramic Type Resistors are being utilized to the utmost to maintain deliveries to the most essential Electronic needs.

When the present crisis has passed we will be able to serve the many industries whose needs at the moment must be subordinated to the war effort.

During these times when demands upon us are heavy and deliveries are scheduled according to priority rating and date of order, your indulgence is appreciated. We pledge our untiring efforts to those who have come to depend upon us as well as others who may need our help.

The condensed table of specifications below will serve to give you a thumbnail picture of the physical and electrical characteristics of the more commonly used types of Globar Brand Resistors.

Resistors having special characteristics to meet specific needs may be made available to those whose circuits require them.

Type	Length		Diameter		Resistance Per Inch Of Length		*Overall Watt Rating		*Normal Rating Watts Per Sq. Inch Of Radiating Surface	Maximum Volts Per Inch Of Length
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.		
"A"	¼"	18"	1/16"	1"	25 ohms	15 megohms	¼ watt	54 watts	1 watt	400
"B"	¼"	18"	1/16"	1"	5 ohms	15 megohms	¼ watt	54 watts	1 watt	400
"CX"	¼"	18"	1/16"	1"	1 ohm	1000 ohms	¼ watt	150 watts	2½ watts	See Note

** These ratings may be substantially increased by artificial cooling.*

1. Type "A" has comparatively Straight Line Temperature-Resistance and Voltage-Resistance Characteristics.
2. Type "B" has Negative Temperature-Resistance and Voltage-Resistance Characteristics.
3. Type "CX" has a slightly Positive Temperature-Resistance Characteristic.
4. Other resistor types are available for specialized applications.
5. Globar Brand Resistors are usually furnished with plain metallized ends for fuse clip mounting, but may also be supplied with wire leads if desired.
6. NOTE: Type "CX" Resistors have a low specific resistance and cannot be subjected to voltage stresses permissible with Types "A" and "B". The maximum allowable voltage is that voltage required to yield the maximum wattage rating for this type of resistor.

Globar Division **THE CARBORUNDUM COMPANY** *Niagara Falls, N. Y.*

REG. U. S. PAT. OFF.

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Erwood Sound Equipment Co.

will be known in future as

THE ERWOOD COMPANY

Because of important engineering advances in the course of our participation in the war effort, our former name no longer describes our broadened program of probable future activities.

The change in name does not include any change in ownership, policy or personnel. Our experienced engineering organization will be maintained intact for the coming electronic era.

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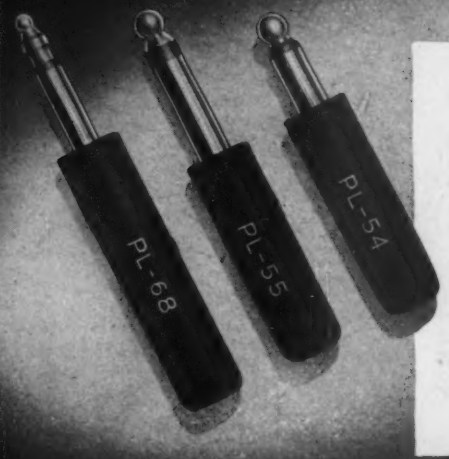

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SPECIFICATIONS

- Also PL—PLP—PLQ and PLS Plugs
- M Type Connectors
- M Type Caps
- FT Type Fittings

Quantity Prices Quoted on receipt of Delivery Schedules

Manufacturers of Communication Equipment
SINCE 1918

REMLER COMPANY, Ltd. · 2101 Bryant St. · San Francisco, Calif.

of short waves by Hertz which led to the development of commercial radio communication. Whereas the short waves of Hertz were gradually increased in length to lower frequencies, the introduction of carrier telegraphy and telephony increased the frequency range beyond that normally required for telephone service until ultimately the two bands merged or overlapped. Recent extension of frequency utilization into the ultrahigh frequency and microwave region would appear to indicate that by the time the war is over, methods will have been devised to open up for effective utilization, the entire frequency spectrum up to and including visible light. At least it is becoming evident that the frequency spectrum normally used for communication, and in which oscillations are intentionally generated by man-made machines, will converge to that region of the spectrum in which oscillation occurs as a result of the motion of atomic or interatomic elements. What the opening of these vast and frequency bands infers can only be surmised at the present time. Certainly the possibility is open for communication services of a type not now employed.

"Radio Production for the Armed Forces," was the title of a paper prepared by, but read in the absence of, Rear Admiral Stanford C. Hooper. Under the compulsion of war improvements which were long sought by the armed services are being achieved, but the manufacturing processes of radio concerns must be altered to meet the requirements of military equipment and this is achieved through the establishment of suitable specifications. "These new specifications reflect the demand for perfect performance; perfect reception by plane flying at 20,000 feet, battling ice and sleet, as well as the enemy; perfect reception by pitching tanks, hurtling debris and jolting through shell holes in the heat of the African desert; perfect reception for all our mobile equipment, whether it be in the Battle of Midway, the Aleutians, or the green steaming jungles in the Solomons.

"These specifications call for equipment that must stand up with full efficiency under all conditions—tropical and arctic temperatures, rapid changes in altitude, varying humidities, salt spray, hot sun and desert sands. It must be unaffected by the

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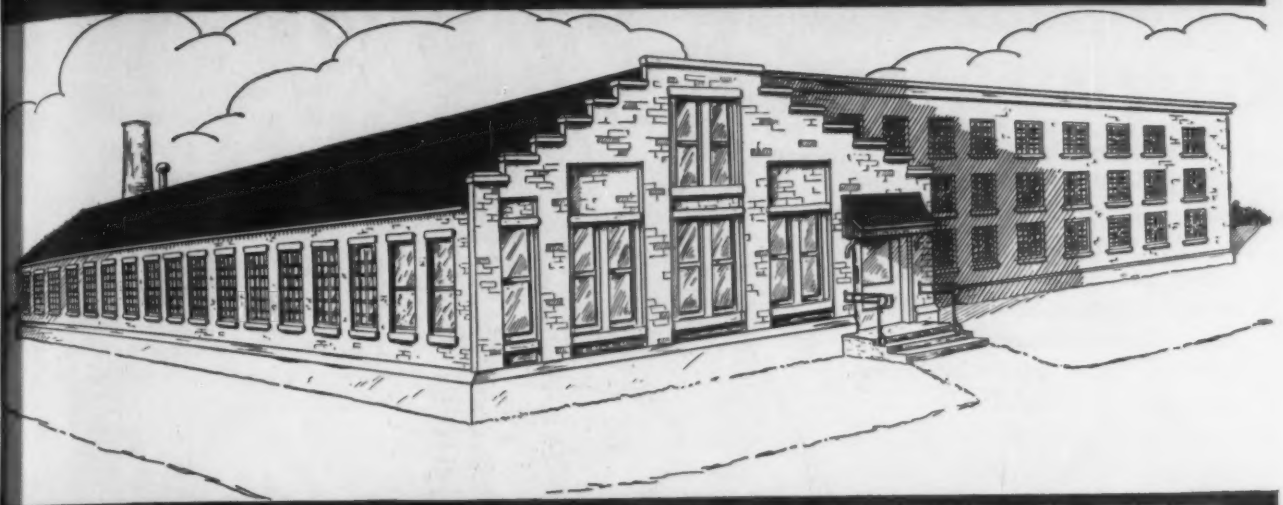
is solving new VOLTAGE CONTROL problems



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This plant is entirely devoted to engineering, manufacturing and development of...

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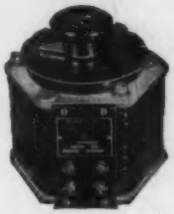


AIR COOLED

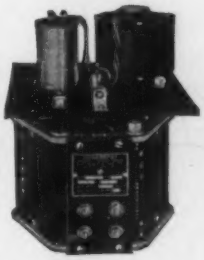
STANDARD TYPE POWERSTAT VARIABLE TRANSFORMERS are available in capacities up to 75 KVA for single or polyphase operation on 115, 230 or 440 volt circuits. Where necessary specially designed units can be built to specifications.

OIL COOLED

COMPLETE ENCLOSURE WITH INCREASED KVA CAPACITY is available in oil cooled POWERSTATS. Many wartime applications require these features in single and polyphase types. These units are manufactured for manual operation or motor drive.

MOTOR DRIVEN AND REMOTE CONTROL POWERSTATS

STANDARD AIR COOLED MOTOR DRIVEN POWERSTATS are made in capacities up to 75 KVA for single or polyphase circuits of 115, 230 or 440 volts. Units of this type are ideally suited for continuous and dustless control of *large amounts of power*. The driving motor is designed for slow speed, eliminating complicated gearing. Applications of these devices include those from *push button type control* of voltage and power in electronic, heating, plating and other fields requiring *automatic correction* of voltage and power output when the device is actuated from special control circuits.



SECO AUTOMATIC VOLTAGE REGULATORS

SECO IMPROVED AUTOMATIC VOLTAGE REGULATORS deliver constant output voltage with variations of applied voltage or load. This design has features of wide range, correction, high efficiency, freedom from mechanical adjustments, zero wave from distortion, low cost per KVA and operation is unaffected by load power factor. Send for bulletin #163.

SEND FOR POWERSTAT BULLETIN 149LE

CRITICAL CIRCUITS, radio, other electronic devices and technical processes REQUIRE a.c. voltage and power control.

Our engineering and sales department will cooperate with you in scheduling delivery of this equipment to meet your requirements. Write for Bulletin #149LE.

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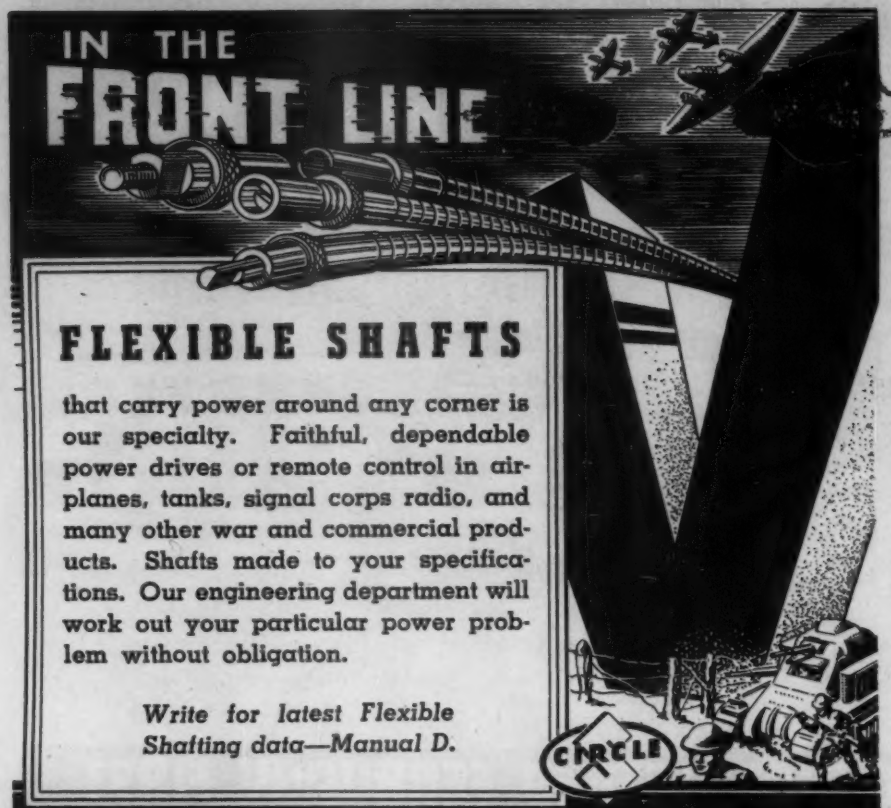

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that carry power around any corner is our specialty. Faithful, dependable power drives or remote control in airplanes, tanks, signal corps radio, and many other war and commercial products. Shafts made to your specifications. Our engineering department will work out your particular power problem without obligation.

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Snug-fitting, non-projecting, TURBO Markers facilitate and make hazard-proof identification of electrical conductors; and can combine insulation requirements.

Available in any size, any length, any color . . . and with any marking . . . they are produced in strict accordance with Army, Navy and Air Corps specifications.

TURBO EXTRUDED PLASTIC TUBING

Incorporating the most advanced developments of the plastics art, as applied to electrical insulation. Especially applicable to conditions wherein embrittlement from the effects of sub-zero temperatures must be met.

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motion of motorized units, ship aircraft, and the jar and vibr due to gunfire and shell attack must be fireproof, especially the instantaneous hot flames w follow a bomb explosion, or in p imity to hot metal surfaces. It m be rugged to withstand mishand and operation by inexperienced sonnel, and jars due to handlin transit. It must be designed to promise ruggedness and extr sensitivity. It must be capable being operated adjacent to var other transmitters and receiver the roar of battle, to electrical other noises of ships and planes, radio jamming. The radiation tubes must not divulge presence an enemy. It must be flexible frequency shifting and power va tion in order that shifts from command or information channel any other may be accomplished required, and instantaneously. must be constructed for installat in most limited space, with minim weight and convenience or ope tion. It must be instantaneou ready for operation at all times, actly on the prescribed freque and accessible for adjustment quick repair. Danger of accident to electric shocks to personnel m be prevented. These are but a f examples to show the need of s cifications more elaborate than th governing the design of commerc equipment."

Because of the constant shift of units from one location to other, the standardization of co ponent parts going into milita equipment is vitally important. Spa parts from various widely separat shore bases which may be co stantly changing, should be ava able for use in ships, planes, tan or submarines if required. T variety of spare parts should be ke to a minimum and "special" co ponents should be used only wh there is no general-purpose subs tute which will meet the requi ments.

"The Army-Navy Electronics Pr duction Agency" was the topic of talk by F. R. Lack, director of th agency. The Army-Navy Electroni Production Agency abbreviat ANEPA has the services of fort four officers and 900 civilians for t express purpose of expediting pr duction for the armed service ANEPA is divided into two bro

RESISTORS ON 24-HOUR WATCH

Electrical equipment aboard ship has no off-duty time. Radio, intercommunication, air conditioning, ventilation, refrigeration, deck machinery, gun operation and innumerable other vital services employ resistors in their control circuits. These resistors must be dependable to function at all times. Ward Leonard Vitrohm Resistors have measured up to their responsibilities. Their ability to withstand moisture, temperature change, shock and vibration makes them particularly well fitted for sea duty. Resistors with the same ruggedness as those used by the Navy and Merchant Marine are available to all industry engaged in victory production. Send for data sheets.

ARMY E NAVY

WARD LEONARD

Electric control (WL) *devices since 1892.*

WARD LEONARD ELECTRIC COMPANY, 32 SOUTH STREET, MOUNT VERNON, NEW YORK

It isn't so today...
"Teresa—Great Hunting ...Fix the guest room....I'm bringing company home!"
"Very Good, Sir... You'll all be here for dinner tomorrow!"
but it will be so tomorrow!

Wartime effort of brawn and brain, man and machine, will determine how far today's producers of Communications Equipment will progress tomorrow.

Today, we are meeting this challenge of war communications needs by helping to produce the finest precision communications instruments manufactured in the world.

These communications instruments are the highest expression of HARVEY-WELLS' skill. Our policy to anticipate the need and keep the lead in developing the finest military Communications Equipment . . . to build for the future after the war when the Communication fantasy that isn't so today — will be so tomorrow.

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HARVEY-WELLS
COMMUNICATIONS
Are Helping to Win the War

★

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HEADQUARTERS
For Specialized Radio Communications Equipment
SOUTHBRIDGE, MASS.

divisions, production expediting and production control and analysis. Mr. Lack pointed out that troubles are few and far between if all orders are made on time and more than 250 expediters of ANEPA are available for assistance on this problem. The snowballing of orders has also resulted in difficulties in the past and the agency has had as one of its functions the tracing out of such "safe guards".

Ray C. Ellis, WPB spoke on "The Functions of the War Production Board in Radio." A portion of this talk was devoted to a resume of the conditions resulting in the formation of the War Production Board. The following abstract, however, deals in practical terms with the present and future which must be faced by those in the electronic industry.

"For the producer of electronic equipment, the major problem for this year lies in finding the engineer, the chemist, and the key production supervisor in sufficient numbers. It is true that the universities have trimmed their liberal arts courses, and that the youth are learning one or another of the physical sciences. However, while many of these young men are studying Maxwell's equations, while they are observing the ways and foibles of the electron, they are also dreaming of themselves in uniform. How many will come to our laboratories and plants? How many will be permitted to stay?

"In general, then, the problem of war production—in radio as elsewhere—is to keep output in line with the requirements of war. That involves the synchronizing of various kinds of output. It requires that the factors of production, namely, facilities, materials, manpower—be available where needed. The WPB, in cooperation with the armed services, are endeavoring to minimize these problems."

Within the radio division there are three groups to handle the three major problems of war production. There is a Program Group which keeps abreast of the requirements for military electronic equipment. Another group, primarily working with the B-1 component, sees to it that critical materials are delivered at the right time and delivered to the right place. A Resources Group makes certain that equipment and facilities of the industry are adequate to meet the schedules which

—MICO—
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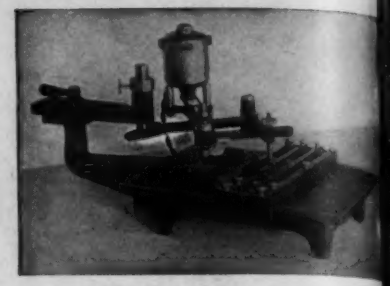

For lettering panels of steel, aluminu brass, or bakelite, or for marki finished apparatus.

A sturdy machine for routine producti as well as occasional engraving.

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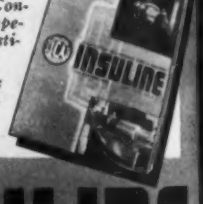
Mfrs. and Contractors: Send specifications for estimates.

Write for this 12-page Industrial Catalog now!



INSULINE
CORPORATION OF AMERICA
INSULINE BUILDING
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Doing the same fundamental Job in 1943 but so much more of it!

ARMY E NAVY

Most manufacturers engaged in war production are working on products foreign to their normal efforts. But it's a different story here at WESTON. We have exactly the same job to do because our job is *so fundamental;* but there's much more, *so much more of it.* For precise measurement is vital to the efficient functioning of equipment in *all* branches of a highly mechanized war machine. And while measurement fundamentals have not changed, the universal preference for instruments the way WESTON builds them *has not changed either.*

So WESTON'S job, as we enter the New Year, still remains the job of striving to keep abreast of the country's unprecedented and critical instrument needs. Production has been increased many fold through expanded and scattered manufacturing facilities. And the curve *continues* upward. But never to the point where we must relinquish, *one bit,* our quality standards — 'else some pilot's safety might be *less* secure . . . a ship's reckoning *less* accurate . . . a critical power plant *less* efficient.

But achieve the production goal *we will;* without jeopardizing quality . . . without interrupting our continuing development program now focused on instruments to help speed victory. And in accomplishing this goal, we will have equipped ourselves to serve *even better* the new and increased instrument needs of the future . . . the needs of American industry at peace. Weston Electrical Instrument Corporation, 618 Frelinghuysen Avenue, Newark, New Jersey.

Laboratory Standards . . . Precision DC and AC Portables . . . Instrument Transformers . . . Sensitive Relays . . . DC, AC, and Thermo Switchboard and Panel Instruments.

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Specialized Test Equipment . . . Light Measurement and Control Devices . . . Exposure Meters . . . Aircraft Instruments . . . Electric Tachometers . . . Dial Thermometers.

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Crystal selection is instantaneous with Signal Corps technicians because Western Electric, Philco, RCA, Howard, Bendix, Bliley Mfg. and other leaders, use Markem's "Husky 6", to simultaneously ink and indent carrier frequency, capacity, calibration and receiver type *in less than one square inch* as clearly as the engraving on a card!

Type changes are quickly made through the master plate; and hundreds of holders come from "Husky 6" every hour with an impression as lasting as the *plastic* or *metal* they're made of.

Why not write for suggestions concerning your marking problems?
Send for catalog E3.

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BOXES, LABELS, TAGS, ENVELOPES, TICKETS, TAGS, LABELS FROM CONTINUOUS ROLLS, COLLARS, SOCKS, STOCKINGS, SHIRTS, SHOE LININGS, TEXTILES, LEATHERS, SYNTHETICS, GLASS, METAL, WOOD, PLASTICS, PRINTED SURFACES, RUBBER SHEETS - ABRASIVES.
SHAPE AND SUBSTANCE PRESENT NO PROBLEMS. There's a Markem machine to identify or decorate every part or product known to industry. And out of the Markem laboratories come special process inks, rotatable type wheels, special type bars or master printing plates so that Markem is the only source of supply you need for marking machines, devices and supplementary materials.

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Builders of Industrial Ink Marking Equipment

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1. MUST WE USE BRASS OR OTHER CRITICAL MATERIAL?

2. MUST WE USE SLOW COSTLY ENGRAVING for MARKING?

ANSWER

1. DO IT ON PLASTIC.

2. USE ROGAN *Deep Relief* **BRANDING.**

The famous Azimuth Navigation Dial is now made of bakelite in place of critical brass. But, it was up to Rogan to calibrate it.

Because Rogan's exclusive branding process is so much faster, so much less costly than engraving, yet equal in every respect to engraved or molded markings, branding the Azimuth Dial is done *exclusively* by Rogan.

Note the tapered sides of the Dial . . . see how clear and sharp the markings appear . . . permanently fuzed with the material to meet every requirement.

BRANDED BAKELITE PROTRACTOR

The bakelite protractor is used in conjunction with the Azimuth Dial. Here again Rogan alone does the branding in *deep-relief* to save time and money.

Your plastic parts of any material, size or shape can be branded successfully, quickly and economically by Rogan.

Get details on Rogan's Combination Molding and Branding service.

ROGAN BROTHERS
2003 South Michigan Ave. **Chicago, Ill.**

have been set. There is a separate group in full charge of the maintenance of our civilian radio equipment. Finally, there is a new "Radio Field Operations Section" working within the WPB Regional Office, which assists the manufacturers and their plants, helping to solve their specific problems outside of Washington.

"An Engineering Advisory Section closely watches the development going on in the laboratories in order that when new devices reach the production stage, there be facilities to undertake the production swiftly; and also that the new designs use the minimum critical materials and components."

The place which standardization is playing in the role of wartime production was outlined in an address "Radio Standards Go to War," by Harold P. Westman, Secretary, War Committee on Radio, American Standards Association. It was pointed out that the aim and function of standards during wartime are quite different from those carried out during times of peace. During peacetime, important standardization may be accomplished on definitions of technical terms, letter and graphical symbols, methods of testing and rating components and equipment, and physical dimensions of equipment.

Wartime standardization must deal primarily with the simplification of practices and the standardization of physical equipment to the aim that the maximum production may be effected. The War Committee on Radio, which is charged with preparing standards for radio components for use in equipment for our armed services, consists of a group of individuals and representatives of the armed services who are skilled in the production processes and requirements for such radio equipment. The drafting of standards is carried out by relatively small groups or committees charged with the responsibility of preparing the proposed standards. Usually a series of drafts are made, each based on criticisms of a previous one. As each draft is completed, it is sent to all known interested groups and individuals with requests for comments. The last draft is circulated in printed form and is made as nearly like the final copy as knowledge at that stage of the work permits.

The following subjects are now on the agenda for standardization:

(a) Components
- Fixed capacitors
- Fixed resistors
- Variable resistors
- Dynamotors
- Tube Sockets
- Crystals and holders
- Vibrators
- Dry batteries

(b) Materials
- Insulating material

(c) Processes
- Soldering metallic surface coatings
- Organic surface coatings

The objective of the foregoing is to produce a series of specifications to provide a range of components suitable for practically all normal designs of radio and electronic equipment for use by the armed services. Additional factors which must be taken into account in any completely successful standardization program include (a) interchangeability of parts among all branches of the armed services, (b) increased production, (c) reduced weight of materials, critical or otherwise, (d) conservation of labor time, and (e) clarity of presentation to avoid unnecessary difficulties between manufacturing and inspection personnel.

Every effort is being made to develop specifications for components which are suitable for operation anywhere on the surface of the earth, below the sea or in the sky above. Any component which is limited to one extreme service as in the arctics or the tropics, presents a serious problem, since such equipment must be earmarked for that particular climate and must be found to be unsatisfactory for replacement use in some other locality.

Of interest to all readers of ELECTRONICS is the final paper of the afternoon session delivered by Kirk Miles, National Roster of Scientific and Specialized Personnel of the War Manpower Commission. The title of Mr. Miles' paper was "The Engineer's Position in the Manpower Program."

Mr. Miles stated that "a number of regulations providing for the deferment of 'necessary men' have been issued by Selective Service. To be classed as a 'necessary man' and thus be eligible for deferment an indi-

THE Transformers that Fly For Navy are subjected to many unusual conditions not found in ordinary operations. Sudden changes in temperature and atmospheric pressure not only have to be dealt with but must be met by lighter and smaller Transformers that carry heavier loads.

Waterproof-Hermetically Sealed Transformers, built by the Chicago Transformer Corporation not only pass the Navy Five-Cycle Salt Water Immersion Test but also other severe operating, pressure and temperature tests set up in our own laboratories.

Manufacturers of all types of Transformers up to 10KVA

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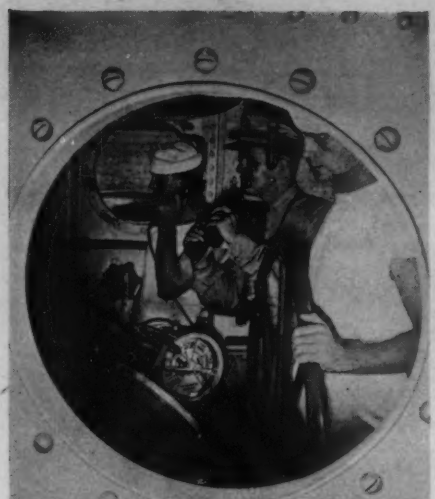


OFFICIAL
U. S. NAVY
PHOTOGRAPH

WHEELHOUSE OF A PC BOAT

Just as the wheelhouse is the nerve center of the swift little PC boats, so radio is the nerve system that links the Navy's ships together.

Like the ships, like the men who man them, the Navy's radio equipment can take it.

NATIONAL COMPANY, INC.
Malden, Mass.

vidual must meet three criteria: (1) He must be engaged in war production or in activities supporting the war effort, (2) he must be in a critical occupation or, in other words, there must be a shortage of personnel of the qualifications and training that if he were removed he could not be replaced, (3) his removal would cause a loss of effectiveness in the activities in which he was engaged."

Through its Military Advisory Section, the National Roster has been giving advice to the Selective Service Board concerning the professional qualifications of its male registrants. If upon consideration of an individual case the Military Advisory Section believes that an individual should be classed as a necessary man, the local draft board is notified of this fact. But this advice is in no way binding upon the local board and serves merely to inform them. The qualifications unit of the National Roster attempts to fill job requests for scientific and specialized personnel that it may receive. It is estimated that since the inception of the Roster some 20,000 to 25,000 positions have been filled in this manner. Although the services of the Roster are available to all, industry has not made as much use of the available service as has the government agencies. It must be understood, however, that with the shortages of skilled personnel, it is by no means possible for the National Roster to be used to find personnel for all jobs which may exist.

Dr. Southworth Speaks on Ultrahigh Frequencies

From many points of view the most interesting address of the I.R.E. Conference was that, held jointly with the American Institute of Electrical Engineers on Thursday evening, at which Dr. George C. Southworth spoke on the subject, "Beyond the Ultra Shorts." In spite of the fact that none of Dr. Southworth's comments revealed any developments subsequent to September, 1939, his able presentation made the subject fascinating to all those who were fortunate enough to attend.

Based on a chart shown on page 157, Dr. Southworth traced the means of developing electromagnetic radiation in various portions of the spectrum from the early works of Hertz throughout the past four or five decades. Progress was rapid from about 1887 to about 1895, after which almost thirty years elapsed before any further significant developments in the generation of short electromagnetic waves was made. While radio physicists were developing generators for shorter and shorter waves, physicists working in the infrared region of the spectrum were developing generators for longer wavelengths until finally about 1923 the spectrum was closed in so far as the physicists were concerned.

But while the physicists may be regarded as the pioneers in developing the need for producing electromagnetic waves of various lengths, the engineers may be regarded as the homesteader since it is its function to occupy and make use of these frequencies. The equipment which the physicists use is not particularly well suited for the engineer's "homesteading activities" and refined apparatus is required. Dr. Southworth traced out the development of continuous wave generating equipment for short waves beginning with the 6 meter oscillator devised about 1916 by W. C. White and extending down to slightly less than 10 centimeters at the time of the European war. In addition to the negative grid oscillator, Barkhausen and magnetron oscillators were also developed and applied in the ultra-short and microwave region.

Another interesting slide shown by Dr. Southworth was one illustrating the transfer of electromagnetic energy from the source to the sink. At commercial power frequencies or even audio frequencies, an iron-core transformer serves the purpose admirably. As the frequency is increased, coupled tuned circuits perform the same function, but with increasing the physical dimensions of the tuned circuits become sufficiently small that ultimately they disappear completely. However, before this stage is reached Lecher wire systems making use of distributed capacitance and inductance may be used to transfer the energy from source to sink. The sending waves on such a wire system may be regarded as representing the impedance of the circuit and hence the analogy to the transformer is complete. As the frequency is still fur-

ther increased, undesired radiation takes place from the Lecher wires. To eliminate this, one of the conductors may be rotated or generated about the other so that a coaxial transmission line is the next step. As the frequency is still further increased, the inner conductor becomes unnecessary and hollow wave guides (or wave guides with solid dielectric material) becomes practical. To carry out the analogy still farther, Dr. Southworth showed the generation and absorption of visible light by means of an optical system with an ordinary lens acting as the conversion element.

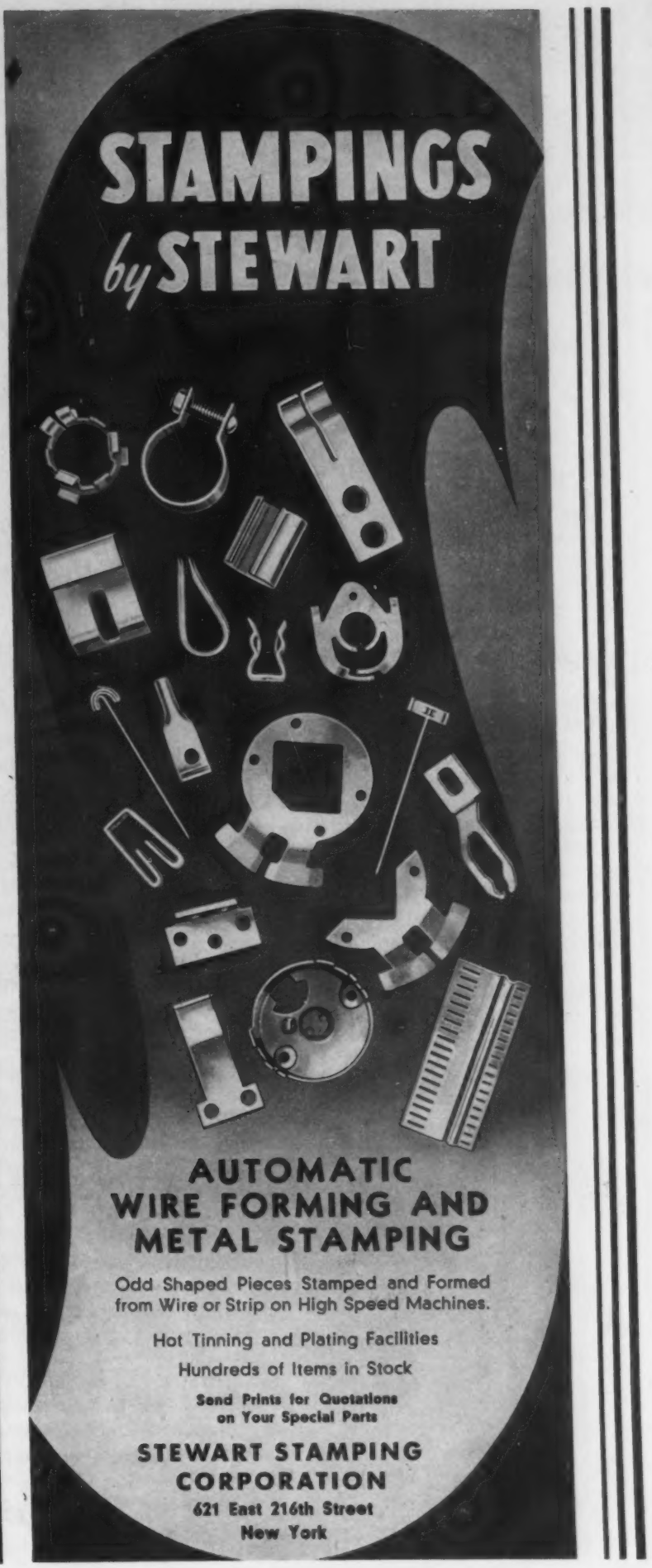
Discussion was also given to the properties and characteristics of hollow wave guides independently and simultaneously developed by Dr. Southworth and by Dr. W. L. Barrow of M.I.T.

In concluding his very interesting address, Dr. Southworth could, of course, only conjecture as to the probable trend of developments. In spite of a lack of new material, even those whose work led them directly into this highly specialized field agree that Dr. Southworth's address was a very lucid and laudable contribution to the complete and thorough understanding of some of the problems "beyond the ultra-shorts."

• • •

ENGINEERS RECEIVE AWARDS

At the meeting of the American Institute of Engineers, held in New York, these three from General Electric Co. were awarded prizes. Left to right, Dr. Geo. W. Dunlap, winner of the Alfred Noble prize; Gerard Swope, president of the company, winner of the Hoover medal; Dr. Willis R. Whitney, first director of the Research Lab., winner of the John Fritz medal. Dr. Dunlap is shown demonstrating the voltage analyzer on which he based his prize-winning paper



NEW PRODUCTS

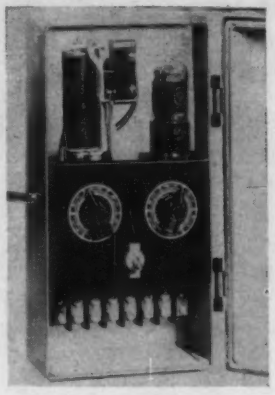
Month after month, manufacturers develop new materials, new components, new measuring equipment; issue new technical bulletins, new catalogs. Each month descriptions of these new items will be found here

Electronic Timers and Reset Timers

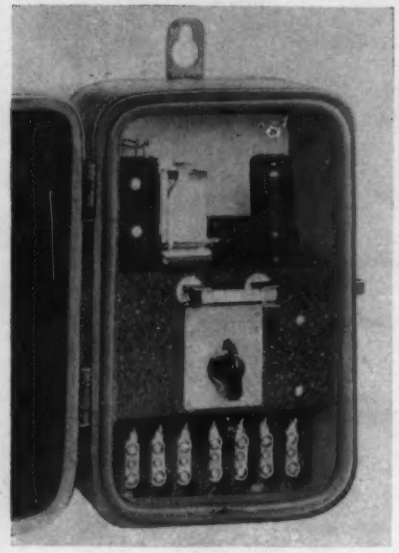
ALL OF THE TIMERS described below are new products available from R. W. Cramer Co., Inc., Centerbrook, Conn.

TYPE ET ELECTRONIC time delay relays are designed for universal application on either a-c or d-c and are for ranges from 1/20 second to 2 minutes. They are designed to operate from any combination of sustained or momentary remote control circuit, and are provided with a separate single-pole double-throw load contact, to permit a wide variation in field use. Their construction includes only one moving element so that wear is reduced. The timers are particularly adaptable to short intervals, repeat cycle timing, where long life is essential. Through a special combination of circuit arrangement (high voltage condensers and low tolerance resistors) interval variation in repeat cycle timing is maintained at less than 2 percent and is practically independent of recycling time. On line voltage variation (as high as 10 percent) the maximum interval variation does not exceed 3½ percent.

By a flexible terminal arrangement it is possible to obtain in the field with either a maintained or momentary start and stop control station, a circuit arrangement in which the load contacts reverse instantly at start of cycle and return to initial position at the end of the expired operation interval. Or with a maintained SPDT control switch, a combination can be obtained in which the load contacts do not function until the end of the operating cycle. Reversal of the control switch resets the timer.



Double Reset Timer



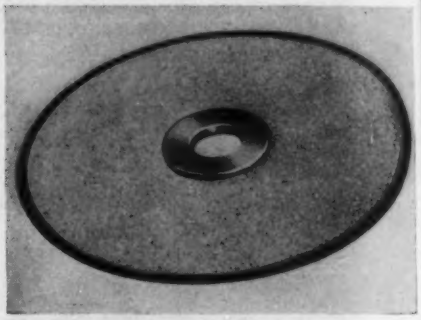
Type ET Time Delay Relay

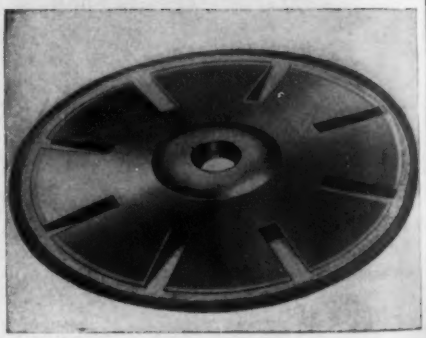
Six timing ranges are available: 1.5, 5, 15, 30, 60, to 120 seconds. Each range is controlled by a small fixed resistor which is snapped into a fuse clip on the timer and which can be readily changed in the field. Resistors should be selected for the shortest interval which will meet anticipated requirements as this permits maximum accuracy in the setting of the dial. Load contacts are rated to carry a ½ hp motor load, 250 watt incandescent lamp load, 1200 watt heater load, or solenoids in which the inrush does not exceed 15 amps at 110 volts a-c or 75 watts non-inductive load on 115 volts d-c.

Other Cramer relays are the TD4 time delay unit for protecting vacuum tube equipment. This is a synchronous motor-driven timer which delivers an accurately measured adjustable time delay. The RS4 and RS5 time delay relays are available in ranges up to 5 hours. Another relay is a double reset type adapted to industrial applications which require rapidly recurrent impulses of a selected duration.

Selenium Rectifier

COMPACT, LONG LIFE, light weight, and electrical and mechanical stability with no moving parts to wear out or cause failure are among the features of a new selenium rectifier. Its outstanding feature is the protection provided against excessive humidity and moisture conditions, encountered particularly in marine service. This improvement is made





Selenium Rectifier Discs. Top, shows single metal washer which facilitates protective coating against corrosion. Bottom, shows conventional petal-shaped brass contact washer

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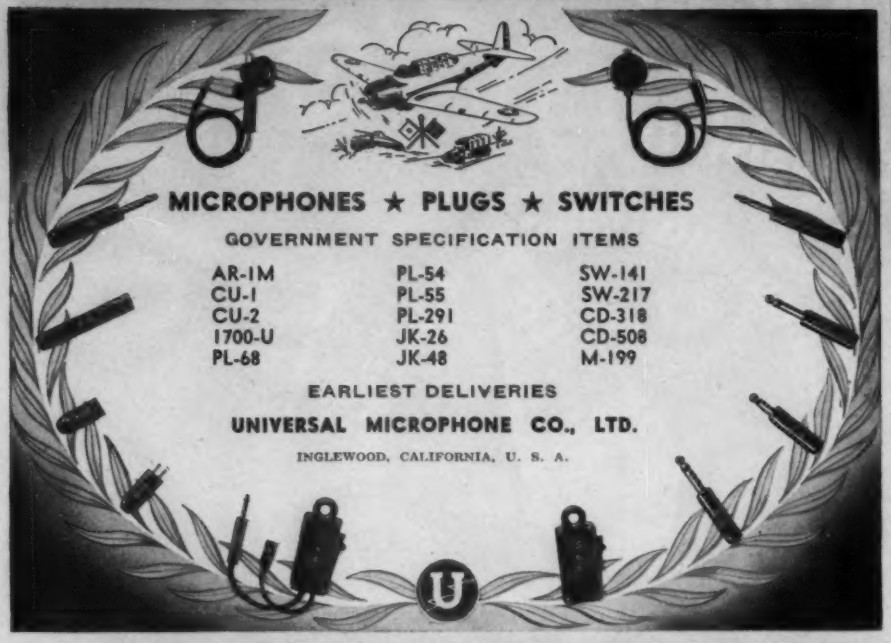

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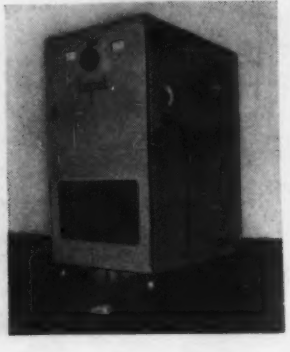

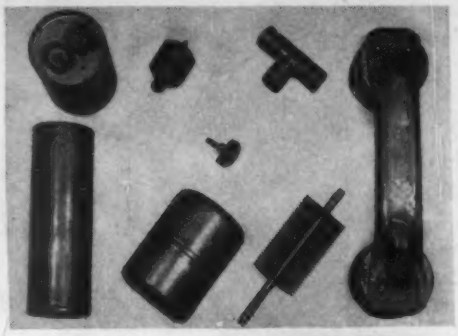

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possible by a special assembly which lends itself more readily to moisture-proofing. Standard brass contact washers and pressure-limiting fibre washers are not used. Instead, a single metal washer is employed which makes it possible to apply the protective coating to all exposed surfaces.

International Telephone and Telegraph Corp., 67 Broad Street, New York, N. Y.

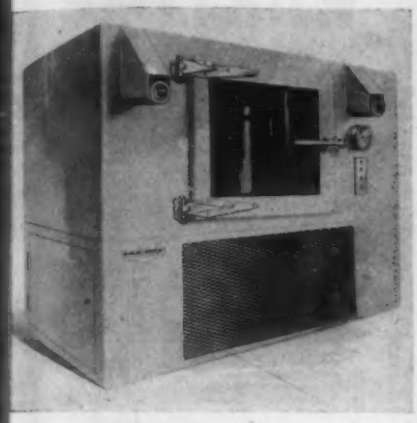
Industrial Sub-Zero Machine

ILLUSTRATED IS basic Model 3600HL (designated as "Hi-Low") machine which is available in three temperature ranges for testing aircraft instruments, batteries, wire, metals and various devices. The machine provides the conditions which are required for testing under certain stringent aircraft inspection and testing specifications.

Temperature ranges available are from −60 deg. F. to +170 deg. F., from −80 deg. F. to +170 deg. F., and from −90 deg. F. to +170 deg. F. In Model 3600HL90 "Hi-Low" machine, for example a temperature drop from ambient of +80 deg. F. to −60 deg. F. can be accomplished in 45 minutes; to −70 deg. F. in 1 hour; to −80 deg. F. in 85 minutes, and to −90 deg. F. in 140 minutes. Also, heating to +170 deg. F. from −90 deg. F. takes 90 minutes; −80 deg. F. takes 85 minutes; −70 deg. F. takes 80 minutes, and from −60 deg. F. takes 75 minutes. The machine itself is entirely self-contained, and requires only a source of electrical power.

Outside dimensions of the "Hi-Low" machine are: height, 84 inches,

epth, 52 inches, and length 94 nches. The net clear usable work- ng space is 46×36×36 inches. Con- tructions inside and out is of 16- auge steel, welded and chemically reated for paint adhesion. Insula- ion is 8 inches of Fiberglas in the ides, top and bottom. For the "Hi" ide of the machine, strip heaters re located in the air stream for de- rosting and rapid heating. For the "Low" side, finned type coils are sed. The forced convection air dis- ribution provides a high degree of ir circulation in working space for apid heat transfer. The condensing nit is 4, 7½ or 10 hp, 2-stage, air- ooled, "Freon-12 or 22 inch machine



s specified. Temperature recording nd controlling instruments are pro- vided to meet usage requirements. The door as illustrated is standard, though several variations in size and location may be obtained as speci- fied. Interior is lighted by two 40- watt Lumiline lamps, one on each side of the door, and controlled from n switch on the right-hand side of the door.

The Kold-Hold Mfg. Co., Lansing, Mich.

Boundary Protection Equipment

A BALANCED CAPACITANCE-operated alarm device called Browning Signal System is designed for use outdoors on property lines either with or without existing fences. A protec- tive curtain is laid down so that any penetration of this curtain sets off an alarm.

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IN 1938, the authors of this book, assisted by James Hillier, developed and built the first compound Electron Microscope in America. Since then, the reports of its accomplishments have literally permeated the scientific world.

This book outlines the basic principles of both optical and electron microscopes. High points in the discussion are graphically illustrated by many original line drawings. After a detailed description of the dual nature of light, its application to the functioning of the electron microscope is clearly shown. In this connection frequent emphasis is placed on the contributions of Newton, Maxwell, de Broglie, and Planck. The book is high-lighted by numerous striking photographs of bacteria and industrial substances such as asbestos, carbon black clays, and oxides. An outstanding, authoritative book that will be read with absorbing interest by all physicists, microscopists, chemists and industrial engineers.

CONTENTS

Vision, Light Microscopes. What is Light? Wave Motion and Wave Motion Media. Wave Theory of Light Accepted. Electromagnetic Theory of Light. The Electron. Dual Theory of Light. Dual Theory of the Electron. Motion of Electrons in Electrical Fields. Electrostatic Electron Mirrors and Lenses. Magnetic Lenses. History of Electron Microscope. Electrostatic Electron Microscope. Applications of Electrostatic Electron Microscope. Compound Electron Microscope-Magnetic Type. What the Electron Microscope Can Accomplish. General Bibliography. Index.

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A HANDY NEW REACTANCE slide rule is available for electronic and electrical engineers, physicists, radio service men, radio amateurs, teachers and students. It saves time solving resonant frequency problems, capacitive reactance problems, inductive reactance problems, Q problems, etc.

On one side of this slide rule, resonant frequency problems are solved with one setting of the slide, using

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On the other side of the slide rule, reactance, dissipation factor and coil Q problems are solved with one setting of the slide, using the following formulae:

$$X_C = \frac{1}{2\pi fC}$$

$$X_L = 2\pi fL$$

$$Q = \frac{2\pi fL}{R}$$

$$D = 2\pi fCR$$

The ranges on this side are 0.1 cycle to 10,000 Mc, 1 $\mu\mu$f to 100 mf, and 0.001 mh to 100 henries.

This slide rule is available at a nominal charge of ten cents in coin or stamps to cover the cost of handling and mailing. All inquiries should be addressed to Shure Brothers, 225 West Huron St., Chicago, Ill.

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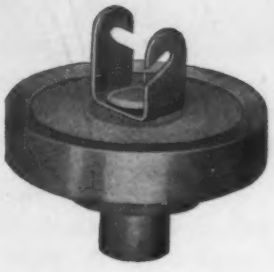
Ceramic Condensers

TWO NEW TYPES OF ceramic condensers, called Disc Ceramicons, have been announced. Basic Type 1770 is ¾ inch in diameter, and basic Type 170 is 1⅛ inch in diameter. The height of the units varies in accordance to capacity (the maximum height, excluding mounting stud and terminal, is ¾ inch). A wide variety of mounting studs and terminals are available. Both types are hermetically sealed to provide protection against humidity.

Type 1770 is rated at 500 volts d-c working, and is available in any standard temperature coefficient from ±120 (P120) to −750 parts per million per deg. C. (N750). Maximum capacity at zero temperature coefficient (NPO) is 1,000 μ and is approximately 7,000 μ in N750.



Type 170 is rated at 1500 volts, d-c working. Maximum capacity in NPO is 400 μ, and 1750 μ in N750.

The manufacturer states that the design of these condensers is such that their resonant frequency is considerably higher than that of conventional condensers and therefore are especially applicable for ultrahigh frequency applications. Copies of a data sheet showing various styles of available mounting studs and giving electrical charac-

LET'S forget about the *uncertainties* of the future and look at a few *certainties*. Tomorrow's radios will be more compact, and more powerful than ever before. Joe Citizen may be tuning around the world himself just as casually as commercial radio does today. He may well complain if a 20-ounce set fails to bring in Australia. And this is certain, too: The Jackson engineers will take part in advancing the science of electrical testing instruments, to anticipate the growing demands of the new radio industry to be reborn after the war . . . Right now Uncle Sam is getting our entire output. And while we are all *in the service*, we'd like you surely to remember that Jackson builds fine testing instruments and expects *always* to be building them.

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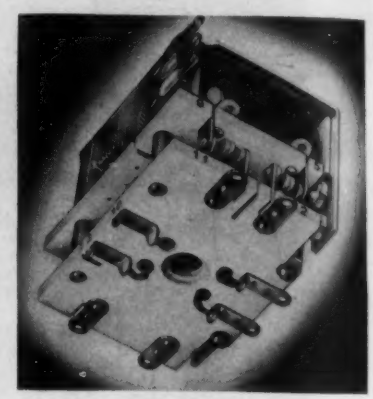
teristics of the Ceramicons can be secured from the manufacturer, Erie Resistor Corp., Erie, Pa.

Keying and Break-In Relay

MODEL AK RELAY is a high speed keying and break-in relay for aircraft radio equipment. It is compactly designed for high voltage, high speed and resistance to vibration. Its push-pull magnetic arrangement provides magnetic holding pressure on both transmit and receive contacts. One pole is equipped with two windings, one of which is a holding winding connected directly across the battery supply. The other winding is connected in series with the single winding on the other pole and polarized so that when the circuit is completed through the key the flux is neutralized on the hold-



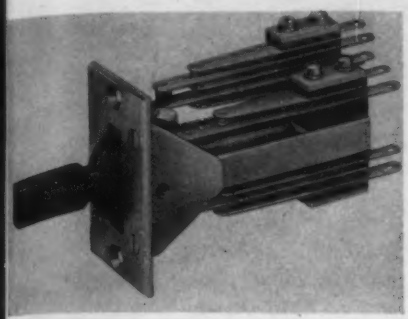
ing or receive position pole and the armature pulls up to the transmit position. Opening the key cuts off the bucking flux and the holding flux pulls the armature back to receive position. The relay is completely balanced.

Other specifications include: Arms which are equipped with anti-bounce features; it is magnetically held in both positions and does not rely on back spring pressure; it keys at 20 cps; its contact rating is 1,000 volts at 30,000 feet, 20 Mc; 4-pole, double-throw; it is insulated to sustain 10,000 volts at sea level; its standard models are in 12 and 24 volts d.c.; its wattage consumption is 5.5 in first position and 17.0 in second position; it withstands vibratory motion to better than 20G.; its dimensions are $2\frac{7}{16} \times 3\frac{1}{8} \times 2\frac{1}{4}$ inches; its weight is 17 ounces.

Allied Control Co., Inc., 227 Fulton St., New York, N. Y.

Lever Switch

MODEL 0–42 LEVER switch is primarily designed for use in aircraft, radio, communications, annunciator and fire alarm systems, testing apparatus, and other industrial applications. It is available in an unlimited series of combinations of contact assemblies. Contacts, pile-ups and lever action are assembled to meet specific requirements. The switch is a rugged, positive action switch, and is light in weight. It has positive action locking, non-



locking (spring return to neutral position) and no-throw stops. A large handle permits a firm grip by a gloved hand. Maximum rating (recommended by the manufacturer) is 5 amps, 110 volts, a-c, non-inductive.

Diagrams and complete information is given in General Data Bulletin No. 82 available from the manufacturer, Donald P. Mossman, Inc., 6133 North Northwest Highway, Chicago, Ill.

Sealed Variable Resistors

TWO NEW CLOSED-COVER, sealed variable resistors, designed to give good performance under humid or dusty conditions, are available for either standard radio or high-frequency equipment.

Type MG resistor is designed for use under conditions of extreme humidity or salt spray, and where internal and external leakage must be held to a minimum. The resistor has a leakage resistance on the order of 300 megohms after 48 hours in 95 percent humidity at 40 deg. C. Spacing of current-carrying parts is greater, and the surface insulation of the molded base is several times that of previous laminated-base units.

Type LP is furnished with a dust-proof cover and is effectively

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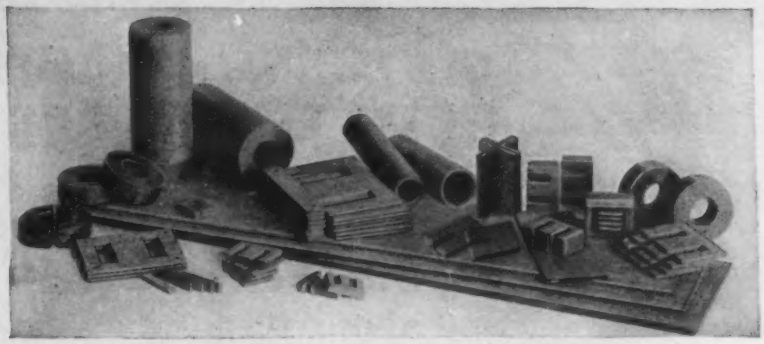

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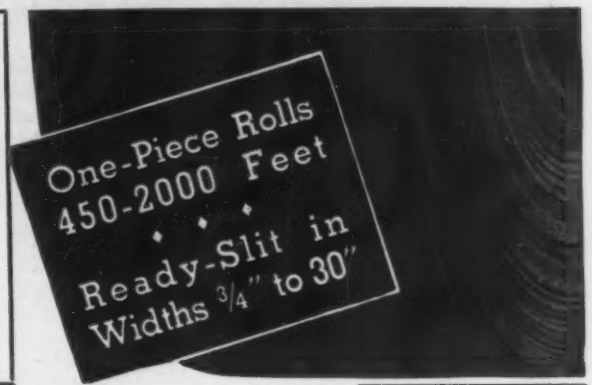

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The information and data in this bulletin are of immediate interest to radio and electronic engineers because remote control flexible shafts have so many uses in connection with radio and electronic equipment. The bulletin makes clear the range and scope of remote control flexible shafts—gives essential data on the wide selection of S. S. White shafts for remote control service—explains how to select the right shaft for any given set of conditions and how to apply it. A copy of Engineering Bulletin 38-42 will be mailed on request. Write for your copy today.

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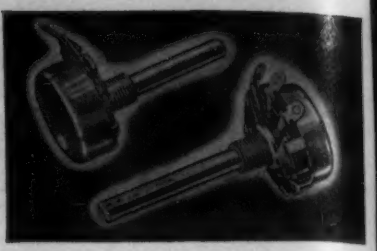


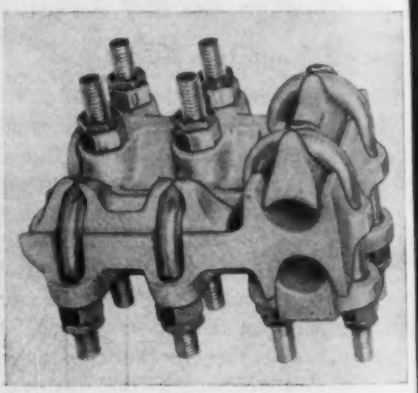
sealed with a special compound to the point where resistivity from current-carrying parts after 48 hours of 95 percent humidity at 40 deg. C. is five times that of the previous open construction units.

Both of the new units have spiral connectors (which give noise-free contact between contacting head and center terminal), as well as a double-fingered element contacting member of special design.

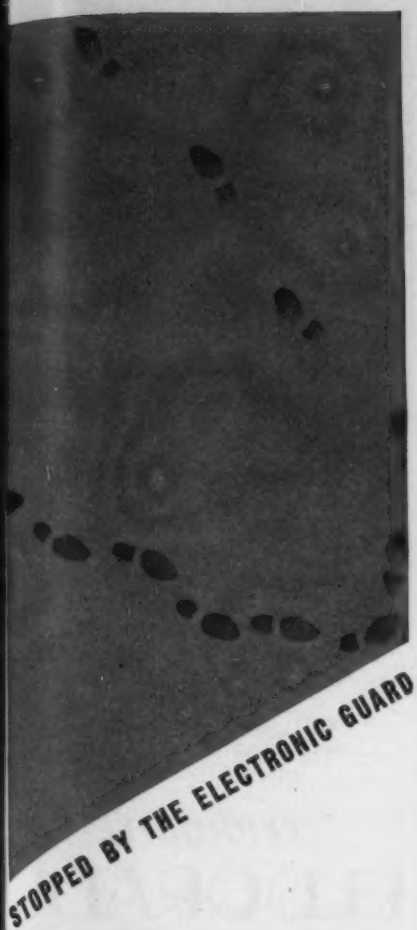
Engineering Bulletin No. 6 describing these variable resistors in greater detail are available from the manufacturer, Stackpole Carbon Co., St. Marys, Pa.

Multiple Cable Connectors

THESE MULTIPLE CABLE connectors have been designed for use wherever cable connectors may be used in place of critical material shortages or to speed up construction work. To provide facilities for connecting and terminating multiple cables, these high compression solderless cable fittings are available in tees, straight connectors, and cable to flat bars, or tubing types. Illustrated is a tee connector for 2-500,000 CM cables on both main and tap. All standard cable sizes can be accommodated up to 1,000,000 CM.



Delta Star Electric Co., Chicago, Ill.



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Literature

Story of Conversion. In this twenty-page booklet, the steps that were taken to convert five automotive plants to airplane manufacturing plants, are given. Some 104 General Motors plants are now engaged in war work and are producing tanks, airplanes, airplane engines, Diesel engines, trucks, guns, shell cases and many other war products. Booklet is available from Dept. of Public Relations, General Motors, 1775 Broadway, New York, N. Y.

References on Aluminum. *Aluminum Service Bulletin*, No. 4, October 1, 1942, contains a selection of references on aluminum. They contain the name of the article, the author, publication it appeared in and the date of publication. Several of the references are available upon request, others may be found at technical libraries. Aluminum Company of America, 2195 Gulf Bldg., Pittsburgh, Pa.

Marking Machines. Advanced marking methods are fully described in an illustrated 8-page folder. Marking machines for informative designations on vari-shaped surfaces; designations on flat surfaces and objects and designations by simultaneous indenting and coloring are included. These machines may be used for marking any size, shape or type of material, such as glass, wood, plastic, metal, cloth, paper, painted surfaces, rubber sheets, abrasives, etc. Markem Machine Co., Keene, N. H.

Electrical Contacts Manual. This booklet (32 pages) has been made-up to be helpful to designers of electrical equipment and appliances. Practical notes on design for better contact performance, descriptions of contact metals, alloys and powder metallurgy compositions and a Contact Selector Chart help in the choice of contact material for a given application. Solid and composite rivets, screws, disks with projection backs for welding, plain and solder flushed disks and segments, bimetals and special service contacts are illustrated and listed in convenient catalog form. Fansteel Metallurgical Corp., N. Chicago, Ill.

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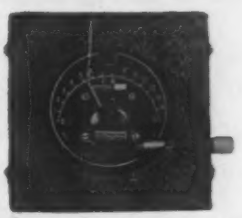

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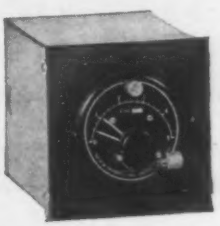

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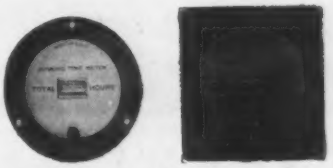

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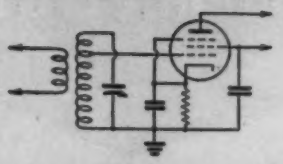

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Melting and Alloying Furnaces. Bulletin No. 500 on magnesium melting, holding and alloying furnaces covers the various types and sizes of furnaces available. The latest furnace added to the line is model MAH with 2000 to 4400 pound capacities in magnesium. Bulletin 500 available from Fisher Furnace Co., 5535 N. Wolcott Ave., Chicago, Ill.

Vacuum Pumps. Faster methods of chucking and handling metals, papers, plastics, wood and other materials is described in a four-page folder. Vacuum pumps, air motors, continuous feed sand blasts and dust collectors are illustrated. Available from Leiman Bros., Inc., Christie St., Newark, N. J.

Sound Devices. The recording of sound for industrial and military purposes is described in this booklet. Details of operation of the different models are included. Described and illustrated are: Type JVC, Type AZ, Type 1K, Type JVD, Type 2VD, Type VA, Type HBK, Type CD and several other models. Available from Miles Reproducer Co., Inc., 812 Broadway, New York, N. Y.

Circuit Breakers. Booklet DD-29-060 describes Nofuse "De-ion" circuit breakers. Breakers are available for panelboards, switchboards, built-in applications, individual mountings and separate enclosures. Special attachments are described and pertinent facts on design and operation of each breaker is given. The booklet also explains how to select the circuit breaker best suited for the application. Diagrams with exact dimensions of each breaker are included. Available from Westinghouse Elect. and Mfg. Co., E. Pittsburgh, Pa.

Speed Reducers. Bulletin 22–27, which supersedes 22–25C, describes speed reducers for 1/50 to 10 hp motors and speeds from 0.08 to 1140 rpm. The applications, dimensions, electrical modifications, frame sizes, formulas, mechanical modifications and price list are included in this 100 page bulletin. Available from Janette Mfg. Co., 556–558 W. Monroe St., Chicago, Ill.

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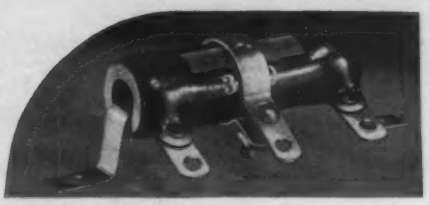
Plastics. "Designing Molded Plastics Parts" is a technical booklet intended for product engineers. This booklet is an enlarged edition of an 8-page booklet issued last year. Data is given on inserts, shrinkage, tolerances, wall thickness, holes, undercuts, ribs, bosses, fillets, threads, assembly devices, materials, physical properties, chemical, thermal and electrical properties. Available from General Electric's Plastics Dept., Pittsfield, Mass.

Metal Duplicating. Catalog No. 43-4 describes the Di-Acro system of metal duplicating without dies. An outline of the system is given with illustrations. Di-Acro shear No. 1, 2 and 3, Di-Acro brake No. 1, 2 and 3 Di-Acro bender No. 1 and 2 are described and illustrated. The representative parts made with the above are illustrated. Catalog No. 43-4 available from O'Neil-Irwin Mfg. Co., Minneapolis, Minn.

Metal Bellows. A new thirty-two page book covers the Cook "Spring-Life" metal bellows. The book is printed in two colors, complete with blueprints, examples of bellows now in use and specification form. These metal bellows are constructed of individually fabricated diaphragms which are joined alternately at inside and outside peripheries. The construction, advantages, characteristics, applications, data enabling the correct selection of a bellows are included. Available from Cook Electric Co., Chicago, Ill.

Media for Draftsman. A booklet which describes a new kind of drafting material for engineers. Engineer's-Glass is plate glass on which drawing paper has been cemented. Drawings can be drafted to permanent charts called Engineer's-Transparencies. These transparencies are scratchproof images on plate glass. As many duplicates as desired can be made from the original design. Booklet available from Industrial Engineers Specialties Division, The Universal Engraving & Colorplate Co., Buffalo, N. Y.



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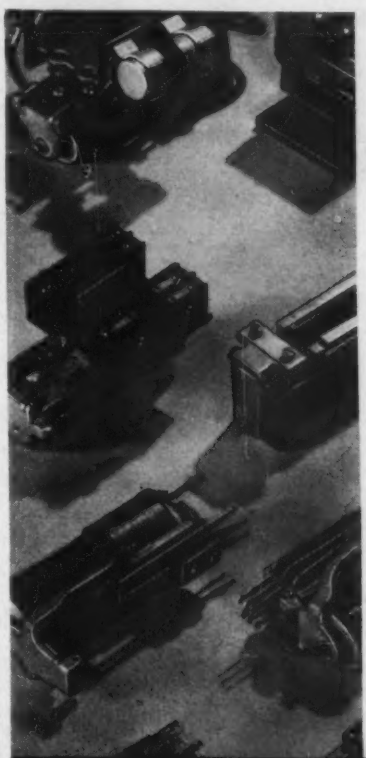

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TUBES AT WORK

Radio Frequency Tool Fires Explosive Rivets..... 310

Balancing Machine Checks Parts in Production.... 310

Analyzer Checks Wiring in "Thunderbolt"..... 314

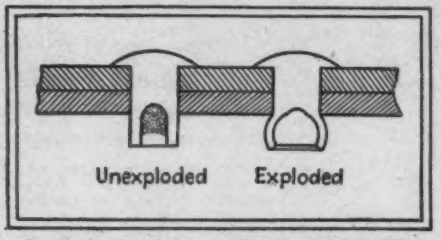
Carrier-Failure and Tone Alarm System..... 315

Resistors Provide Interlock for Relays..... 317

Radio Frequency Heating Tool Fires Explosive Rivets

AN R-F OSCILLATOR capable of firing as many as twenty explosive rivets a minute has been developed by RCA engineers to speed up aircraft assembly. The oscillator is used with a special applicator designed to concentrate radio waves directly in the head of the rivet. The resulting heat due to generation of eddy currents in the rivet is transmitted to the charge of high explosive secreted in a cavity at the end of the rivet shank, firing the explosive and thereby expanding the inaccessible end of the rivet.

The importance of being able to set rivets from outside is evident from the fact that all-metal pursuit planes have as many as 800 fastening points which are accessible only from one side, and the largest bombers have about 10,000 of these points.



Application of the newly developed RCA radio frequency rivet-firing tool to the head of an explosive rivet sets off the charge in a few seconds, expanding the inaccessible end of the rivet

Electronic or "radiothermic" detonation of explosive rivets is proving superior to the use of a solder ing-iron type of rivet-firing tool be cause there is no warm-up time, and the power output control can be ad justed instantly to suit the require ments of different sizes of rivets. Any number of rivets can be put in place ahead of the riveter and held by scotch tape, since this tape does not interfere with r-f heating.

Balancing Machine Checks Rotating Parts in Production

UNBALANCE in rotating parts weighing up to 200 lbs. may be located and measured with the aid of a machine made by the Gisholt Machine Company. This machine, one of several available types, measures pure static and pure dynamic unbalance or the combined effect of both static and dynamic unbalance in two arbitrarily selected planes of correction.

Mechanical Analogy

The operating principle employed by the machine when making measurements in two planes is best described by using a mechanical analogy. Referring to Fig. 1, the part to be balanced is represented as a cylinder which is supported on flexibly mounted bearings *A* and *B* and

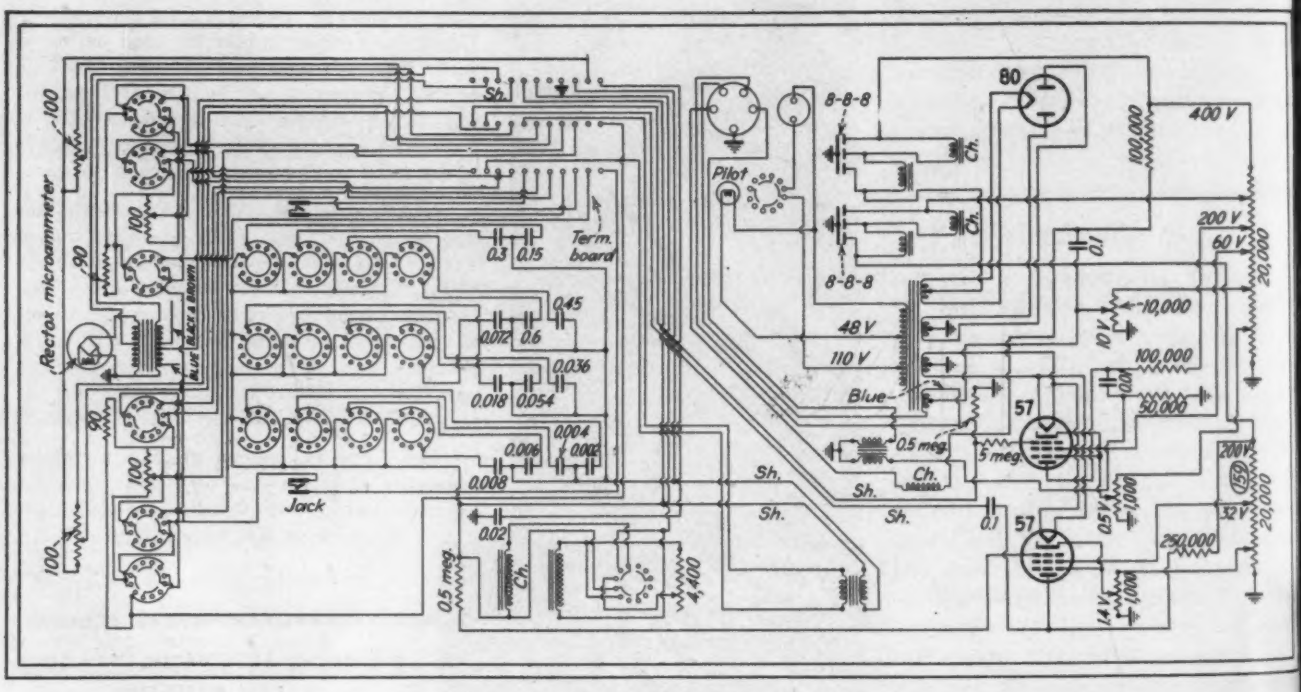
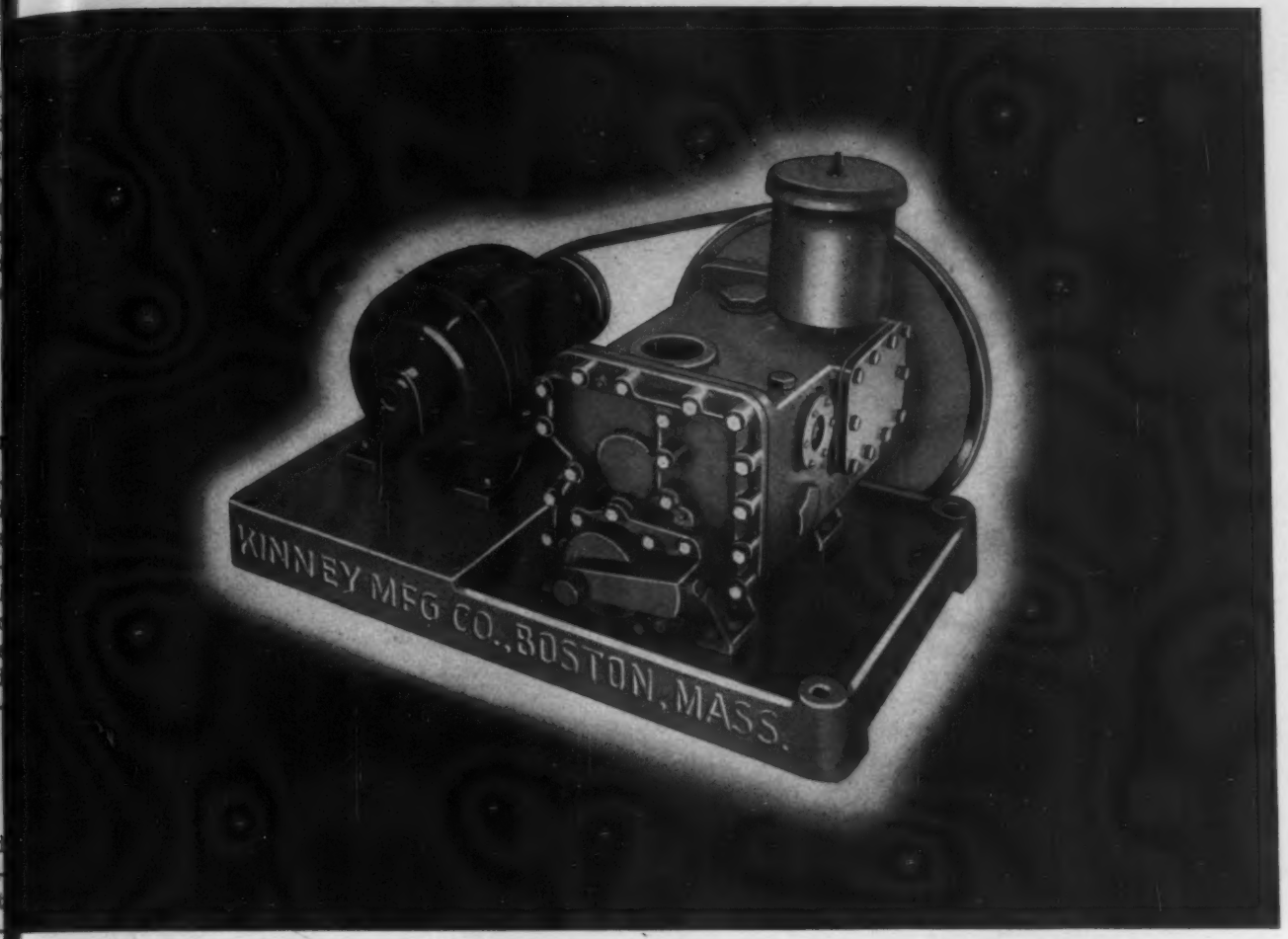


Fig. 4—Detailed circuit diagram of Type S balancing machine whose operating principle is outlined in the accompanying text



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rotated by a motor. The transverse planes 1–1 and 2–2 represent arbitrarily selected planes where corrections may be conveniently made. To correctly measure the unbalance W_1 in plane 1–1 by noting the movement of the supports A and B the portion of movement of these supports caused by unbalance W_2 in plane 2–2 must be eliminated.

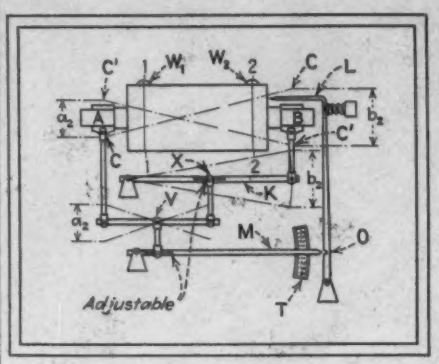

Fig. 1—Mechanical analogy showing method by which Type S Gisholt "Dynetric" machine checks unbalance in two planes and gives independent quantitative data concerning each of the planes

First, assume that the cylinder is balanced. Then insert unbalance W_2 in plane 2. Under rotation, due to the presence of unbalance W_2, the axis of the cylinder will oscillate between lines C–C and C'–C'. The vibration or movement b_2 of support B will be greater than movement a_2 of support A. The vibration or movement of each support will be proportional to the unbalance W_2 and the direction of motion of support A will be opposite to the motion of support B.

Assume that there is a lever K pivoted at one end and attached to support B at the other end so that it will oscillate from the motion of the support. There will then be a point X on lever K which will have the same amount of movement as support A but opposite in direction. The lever V is provided to combine the motion of lever K and support A. One end of the lever V is attached by means of a link to point X on lever K. The other end of lever V is attached by means of a link to support A. Therefore, the ends of lever V have the same amount of motion but in opposite directions. The mid-point of this lever will have no motion even though supports A and B are vibrating due to the effect of unbalance W_2 in plane 2–2.

Now, if an unbalance W_1 is inserted in plane 1–1 there will be a large vibration of support A and of the end of lever V connected to this support. The motion of support B due to unbalance W_1 will be small and the motion of the end of V which is connected through lever K to support B will be extremely small. Therefore, the mid-point of lever V will have a definite amount of motion which will be proportional to the unbalance W_1 and will not be affected by the unbalance W_2. With two such lever systems (one for each end) the exact unbalance in any two selected planes can be accurately determined and the indications for each plane will be true and free from the effect of any unbalance in the other plane.

The motion of the mid-point of lever V is greatly amplified by lever M and the amount of this amplified motion may be read on scale T. This will give an accurate indication of the amount of unbalance W_1 without any influence from the unbalance W_2. As the amount of amplification may be varied by changing the length of lever M, the value of the units on scale T could be adjusted to read in practical correction units.

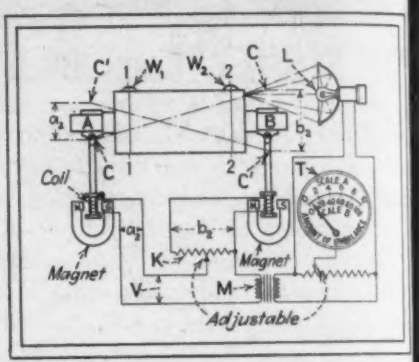

Fig. 2—Elementary circuit of Type S balancing machine, indicating method of employing electronic rather than mechanical components to increase sensitivity and accuracy

The angular location of unbalance W_1 is recorded on the work by means of the centerpunch L, attached to the end of a long, vertical spring-loaded lever which continuously tends to force the center-punch into the work. At the mid-point of the movement of level M its point enters a vee notch O, permitting the center-

punch L to strike the work at two points 180 deg. apart and record the exact angular location of unbalance W_1, thus indicating the points where weight is to be added or removed to obtain balance. When the amount of unbalance indicated on scale T is applied in plane 1—1 at the angular indication given by center-punch L the part will be in balance except for unbalance W_2.

Electronic Counterpart

A functional diagram of the electronic means of locating and measuring unbalance is shown at Fig. 2. Here the work-piece is again represented as a cylinder which is carried

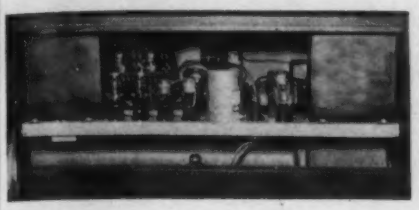

Fig. 3—Photo of back of Type U machine, showing most of the electronic components

in flexible supports at A and B. Attached to supports A and B are coils which are in the fields of permanent magnets. The vibration of the supports due to unbalance causes voltages a_2 and b_2 to be generated in the coils. The voltages thus generated are proportional to the vibrations of supports A and B.

Again assume that the only unbalance in the work-piece is the unbalance W_2. When the work is rotated, the unbalance W_2 will cause a large motion of the support B and will generate a correspondingly large voltage b_2 in the coil connected to support B. The lesser motion of support A will cause a smaller voltage a_2 to be generated at the left-hand coil. By means of the voltage-divider K a portion of b_2 may be chosen which will be equal to a_2 but opposite in value so that the resultant voltage V will be zero due to unbalances of any magnitude in plane 2.

An unbalance W_1 in plane 1 will produce large motion of support A, correspondingly large voltage a_1, small motion of support B and small voltage b_1. Now, if the voltage a_1 and a small part of the voltage b_1 is added, there will be a definite voltage V due to unbalance W_1 with no

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effect from unbalance W_2. This voltage V may be amplified in the Type S machine as much as 1,600,000 times by electronic means at M. The resulting voltage, or any desired portion of it, is applied to an "amount" meter which indicates the amount of unbalance in the work. The amplication used is determined by practical requirements. The meter reading may indicate, for example, the depth in $\frac{1}{64}$ in. units for a given size of drill, or the number of $\frac{1}{32}$ in. lengths of $\frac{1}{8}$ in. diameter solder, required for balancing the rotating part under test.

The angular location of unbalance W_1 is determined by means of Stroboglow lamp L. This lamp is caused to flash for ten millionths of a second each time the voltage generated in the pickup coils changes polarity. The flashing of the lamp at each revolution of the work-piece causes one point on the periphery of the work-piece to apparently stand still. If numerals are placed on the work-piece the numeral which apparently stands still due to stroboscopic effect may be made to indicate the angular rotation of the unbalance correction.

Fig. 3 is a photograph of the back of one of the Gisholt balancing machines (Type U), showing most of the strictly electronic components.

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By JOSEPH HEROLD

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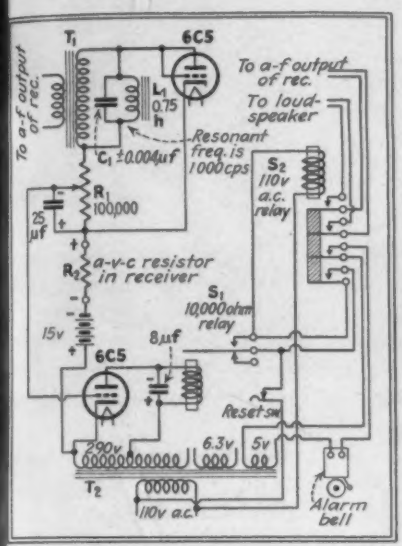

Complete circuit diagram for a carrier-failure and tone alarm system suitable for use at broadcast stations

the receiver, and the other is made to the a-f output of the receiver, as shown in the circuit diagram. When the alarm is set off for any reason, the loudspeaker is automatically connected to the output of the receiver for aural monitoring until such time as the alarm system is reset by means of the reset switch.

The alarm bell circuit is closed by relay S_2 when relay S_1 releases. Relay S_1 is energized by the plate current of the lower 6C5 tube in the diagram, and this current in turn is determined by the net C bias voltage of the tube. Three distinct voltages in series determine the C bias:

(1) A fixed d-c voltage of 15 volts obtained from a C battery, making the grid negative with respect to the cathode.

(2) The d-c voltage across the a.v.c. resistor (R_2) in the monitor

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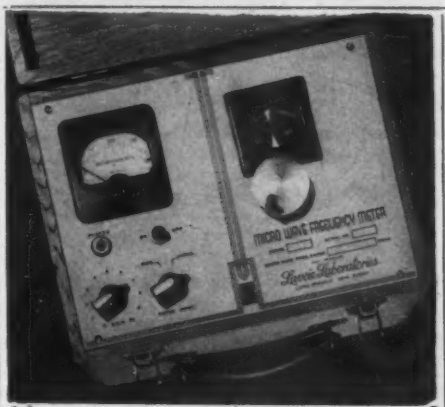

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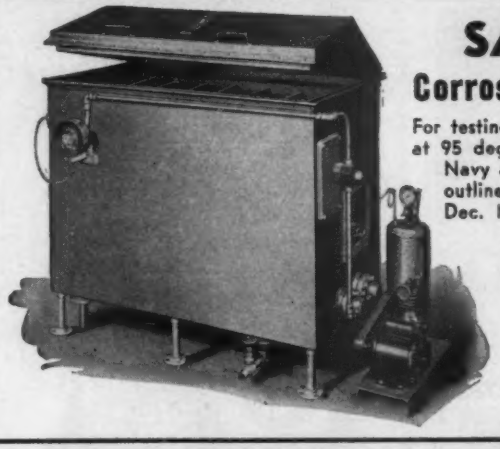

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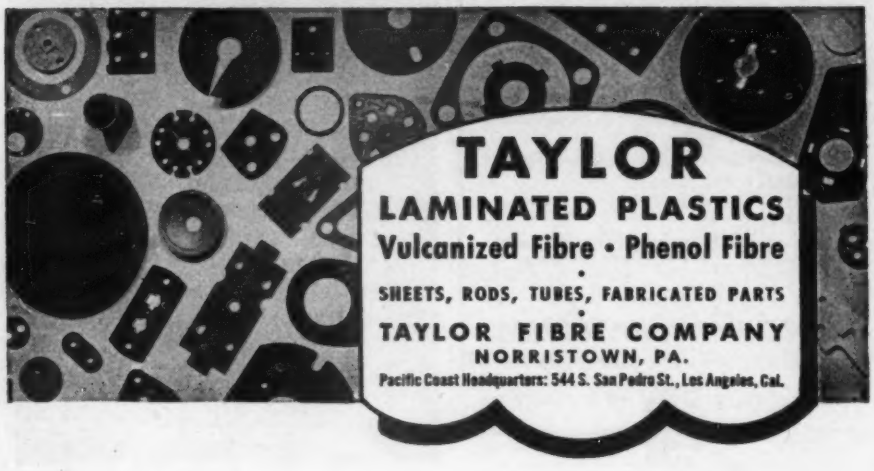

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receiver, utilized in such a way that it opposes the C battery voltage. When the carrier signal is present, the resulting voltage across R_1 lowers the net C bias voltage, allowing enough plate current to flow through relay S_2 to energize this relay and keep the alarm circuit open. Conversely, failure of the carrier opens relay S_2 and closes the alarm circuit.

(3) The d-c voltage across the lower portion of potentiometer R_2 is utilized in such a way that it aids the C battery voltage. When a 1000-cycle tone signal is received, it is rectified by the upper 6C5 tube acting as a diode detector, producing a d-c voltage across R_1. This voltage aids the C battery voltage, increasing the net C bias and lowering the plate current of the lower tube, so that arrival of the 1000-cycle tone releases relay S_1 and sets off the alarm.

Parallel resonant circuit L_1-C_1 is tuned to 1000 cycles, and hence this stage accepts only this one frequency. A 25 μf electrolytic condenser across the lower portion of R_1 provides a time delay of about 5 seconds at this frequency, thus preventing strong 1000-cycle components in a program from setting off the alarm.

The parallel resonant circuit should be tuned quite accurately. This can be done by connecting a d.c. voltmeter across R_1, feeding a 1000-cycle tone to the input of the upper 6C5 stage, and adjusting the value of C_1 above and below 0.004 μf with small mica condensers until a maximum voltmeter reading is obtained.

An ordinary plate-to-grid audio transformer is used for T_1, and T_2 is a standard replacement power transformer providing the indicated voltages.

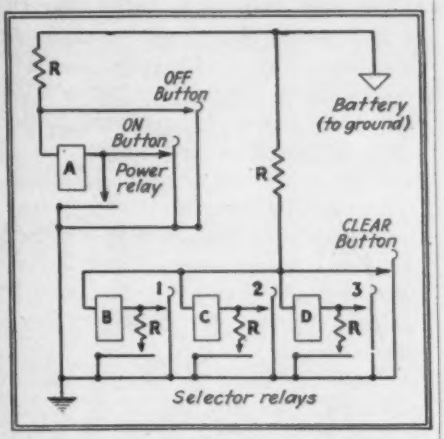
Relay S_1 can have a coil resistance of about 10,000 ohms, and should operate on a change of about 0.003 amp. Relay S_2 is a 110-volt a-c unit having a four-pole, single-throw contact arrangement.

Adjustment of the system is simple. With a carrier signal present and with the system connected to the receiver as shown in the diagram, turn up control R_1 until the alarm is set off by program peaks. Now lower the setting of this control a small amount and press the reset button, repeating the procedure until the alarm is no longer set off by program peaks.

Resistance Network Provides Interlock for Simple Relays

By JOHN H. MILLER

THE SIMPLE INTERLOCK circuit to be described has been used for some years in a pushbutton-operated remote receiver located in the basement of the writer's home. Only conventional d-c relays are needed, as interlock is obtained through the use of a resistance network.



Circuit arrangement for a remotely-controlled pushbutton tuning system which utilizes electrical interlock through resistors instead of conventional mechanical interlock

The diagram is shown above. When the ON button is pressed, power relay *A* picks up. The holding contact then keeps it closed, and other contacts on the relay (not shown) apply power to the receiver. Pressing the OFF button short-circuits the relay and releases the armature, thus turning off the receiver, and a resistor in the battery circuit limits battery current to a safe value during this operation.

After the power circuit of the receiver is closed by pressing the ON button, the button for the desired station is momentarily pressed. Assuming button 2 is chosen, it energizes relay *C*. The resistance in the holding circuit of this relay is low enough to keep the relay closed after the button is released. Other contacts on this relay (not shown) connect the correct padders across the tuning condensers for reception of the desired station.

If another station-selecting button is now pressed, such as button 3, the battery current will initially divide between relays *C* and *D*, with

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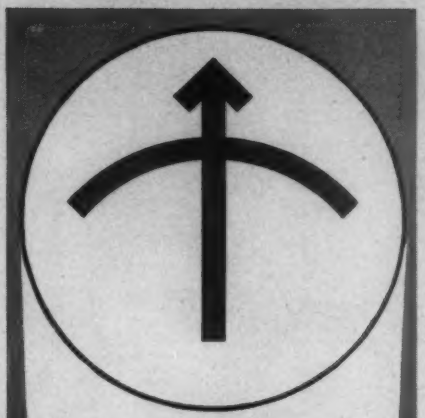

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more current flowing through the newly-selected relay *D* since there is as yet no resistance in its circuit. The current through relay *C* and its holding-circuit resistor is lowered sufficiently for this relay to drop out. The holding circuit of relay *D* takes over after button 3 is released, and the new station is thus selected without any need for manual interlock.

The release of one station-selecting relay concurrently with selection of the next can best be explained by using actual values. Assume the resistance of each relay coil to be 10 ohms, assume that each resistor *R* in the network is 10 ohms, and assume that the battery or other voltage source provides 6 volts. Now, when button 2 is pressed, 0.3 amp flows through relay coil *C* and battery circuit resistor *R* initially. When the button is released, this current drops to 0.2 amp due to insertion of the holding resistor in the circuit, but this current is sufficient to keep relay *C* closed.

When button 3 is now pressed, 0.24 amp flows through relay *D* and pulls it up, while the current through relay *C* drops to 0.12 amp and it consequently drops out.

Under these conditions, the selector relays must be able to pick up on a current of 0.24 amp, must hold for 0.2 amp, and must drop out on 0.12 amp. This apparently is not a difficult specification to fill. If a lower drop-out current value must be used, the resistor values can be increased. The 10-ohm values mentioned above are those actually used in the installation mentioned.

The CLEAR button is provided to short out the last selector relay and deenergize it when the receiver is turned off. It should be pressed when the OFF button is pressed, for otherwise current would be drawn by one selector relay when the receiver is not in use.

Instead of a battery, the writer used an ordinary bell-ringing transformer acting through a small copper-oxide rectifier of the type found in trickle chargers. This permitted the use of ordinary d-c relays without attendant battery replacement problems.

The only difficulty encountered in several years of operation was dust in the padder contacts of the relays, causing noise in the receiver. Cleaning and adjusting of contacts about twice a year has proved sufficient.

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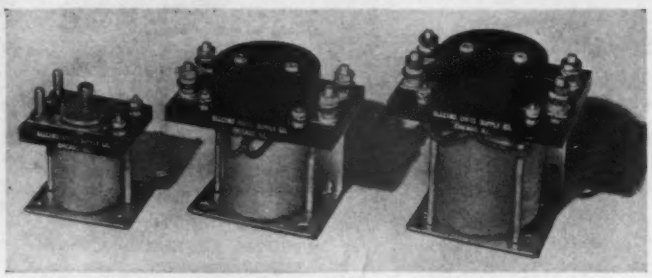

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Radio Goes to War

By CHARLES J. ROLO, *G. P. Putnam's Sons, New York, 1942, 293 pages, price $2.75.*

TECHNICIANS IN ELECTRONICS are well acquainted with the military use of radio in the field, on ships and in planes. However, one very effective use of radio as an offensive weapon usually receives little or no attention. This use is on the propaganda front. This is the subject of Mr. Rolo's well written book.

In twenty-three interesting chapters he tells how the enemy is using radio propaganda, how we have come to realize its importance, and how we are retaliating in kind. The reader is taken on a tour of the air waves to the various propaganda centers where "bombs for the mind" are being prepared and launched every day and every hour. The technique, (so potent in well-trained hands, as is exemplified by the collapse of propaganda ridden France) is explained and many interesting cases are cited.

Radio as a propaganda weapon is gaining in importance every day. This book tells how and why. It is heartily recommended. Mr. Rolo's informal style makes interesting reading. The chapter on secret radio stations is especially good.—E.E.G.

• • •

The Electrical Fundamentals of Communication

By A. L. ALBERT, Professor of Communication Engineering, *Oregon State College. McGraw-Hill Book Company, New York. 550 pages. Price $3.50.*

IT WOULD BE DIFFICULT to define the scope and classify this volume more aptly than the author has done in its preface from which the following quotation is taken:

"The title of this book, 'The Electrical Fundamentals of Communication,' defines its scope. It presents the electrical fundamentals upon which communication, including the three divisions telegraphy, telephony and radio with its allied branches, is based.

"The book is designed for the student of communication and the worker in the communication industry. It considers electrical phenomena, using explanations and illustrations taken from the communication industry itself. In this respect it differs from other books on electrical fundamentals which include explanations and illustrations largely drawn from the power industry."

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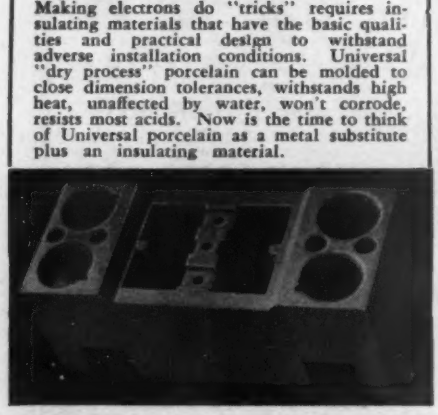

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fundamentals of electrical communication are largely descriptive. Indeed, every high-school graduate with an acquaintance of trigonometry and algebra should have no difficulty with the text. Thus, it would appear that this volume is admirably suited to the needs of many persons who are required to acquire an understanding of the principles of communication under the present training program. Nevertheless, the text is as rigorous as such a treatment permits. The directness with which each topic is attacked, the clarity with which electrical fundamentals are elucidated, and the pleasant reading of the text are attributable to the author's experience as a technical writer and teacher.

To this reviewer it appears that the complete elimination of hydraulic and mechanical analyses to represent electrical concepts is a distinct step forward. "The reader is presented the facts in electrical language and will learn them correctly the first time, instead of being obliged to study vague and inadequate analyses taken from other fields." Another commendable feature of this volume is the successful and straight-forward explanation of the difference between the direction of flow of an electric current in the conventional manner and that based on the electron theory.

The sixteen chapters provide a well-balanced outline of electrical theory and principle. Throughout, emphasis has been placed on an understanding of the essential concepts involved and the glitter and tinsel of that phase of "practicality" which so easily leads the student to believe that he has a greater understanding of electrical fundamentals than is actually the case, is conspicuous by its absence. There are no diagrams of complete telephone systems, or radio receivers, or public address systems which the reader can construct from parts purchased at the local radio supply house. But one who has conscientiously read and studied this volume cannot but help having a good insight into the electrical fundamentals of communication.

In physical make-up the volume is well done. The author has provided a summary of each chapter which outlines the highlights. This should prove useful to the student who desires to make a quick review of material he has studied. At the same time each chapter is provided with a number of review questions requiring written answers of the discussion type. In addition, a number of problems, without answers, are provided by which the student can check, through numerical computation, his understanding of the quantitative relationships covered in the various chapters.

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By ISABELLA M. COOPER. *University Chicago Press. 1942. 576 pages. Pric $5.00. Offset. Format, 8½x11 inches.*

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